

# *Culicoides* Biting Midges (Diptera: Ceratopogonidae) of Kenya

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**ABSTRACT** The 55 known *Culicoides* species of Kenya, including the adult females of 52 species and the adult males of 46 species, are described. New taxa described for Kenya include *C. ischnoensis* n. sp. (subgenus *Meijerehelea*), *C. karenensis* n. sp. (*similis* group), and *C. nairobiensis* n. sp. (*inornatipennis* group). Three new species of the *C. schultzei* group are left unnamed. The Kenyan fauna is arranged in five recognized subgenera (10 species), eight species groups (36 species), and nine unplaced species. Comprehensive taxonomic keys are included for adult females and males; and sections in the treatments of each species are devoted to synonymy, type material, diagnosis, descriptions of the adult female and male, subgeneric or group status, larval habitats, adult seasonal and ecological distribution, host preferences and biting habits, medical importance (if appropriate), geographic distribution, and material examined. Line drawing illustrations of females of 52 species and males of 45 species are presented; they include the head, antenna, maxillary palpus, mandible, legs, wing, and spermathecae of females, and the genitalia of males.

**KEY WORDS** Insecta, biting midges, Kenya, systematics

*Culicoides* is the most significant genus of the Ceratopogonidae with respect to human health. These midges usually are a serious nuisance to humans because of their painful bite and ensuing reactions in sensitive individuals. In many areas of the world, *Culicoides* midges affect economic growth and tourism, particularly in the Caribbean (Linley & Davies 1971). Excellent reviews of the medical and veterinary importance of the genus *Culicoides*, including the ability of certain species to transmit filariae and protozoa, have been made by Kettle (1965) and Braverman & Galun (1973a).

*Culicoides* are vectors of viral diseases in domestic animals and humans. Isolation of half of the known Simbu group arboviruses has been made from *Culicoides*. Two of these viruses cause human disease, including Shuni virus (Nigeria, South Africa) and Oropouche virus (Trinidad, Brazil, Colombia) (Berge 1975). Isolations of Rift Valley fever virus from *Culicoides* pools in Nigeria (Lee 1979) and Kenya (Davies & Highton 1980) indicate that *Culicoides* may play a role in the epizootic cycle of the disease.

Before 1970, only two published keys were available for the identification of adult *Culicoides* of the Afrotropical Region (Colaco 1946, Fiedler 1951). Both of these keys were based on species occurring mainly in South Africa. Khamala & Kettle (1971) published an excellent account of the *Culicoides* of East Africa and provided keys emphasizing the fauna of Kenya, Tanzania, and Uganda; however, their paper contains misidentifications and problems with synonymy. A definitive

systematic manual of the *Culicoides* of Kenya is needed to provide accurate identifications of the species encountered in the field and for virus isolation and transmission studies.

## Taxonomic History and Group Systematics

Khamala & Kettle (1971) gave an account of the species of *Culicoides* of the Afrotropical Region, particularly of East Africa, described by Austen (1909, 1912), Kieffer (1913), Carter et al. (1920), Ingram & Macfie (1923, 1925), De Meillon (1947), Macfie (1947), Clastrier (1959), Clastrier & Wirth (1961), and others. Before the study presented here, only 16 species of *Culicoides* had been recorded from East Africa (Kenya, Tanzania, and Uganda), although numerous species had been described from other areas of the Afrotropical Region. Boorman & Dipeolu (1979) provided a taxonomic review of the West African (Nigerian) species.

Classification of the genus *Culicoides* into subgenera, as for Nearctic species, is unsatisfactory when applied to the fauna of the Afrotropical Region because of discrepancies in adult morphology. Khamala & Kettle (1971) treated 61 species of *Culicoides*, 25 of which were described as new and 42 of which were found in Kenya. They used only species groups, even though they referred to the similarities of some groups to Nearctic or Palearctic subgenera.

In the study presented here, the subgeneric and group systematics of the *Culicoides* of Kenya were developed by assembling the species into distinct monophyletic groups on the basis of correlated characters in the adults. Key characters for the female include the wing pattern, arrangement of antennal sensillae, the type of sensory pore on the third palpal segment, degree of eye separation, and the number and shape of the spermathecae. The

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taxonomic key to the adult male *Culicoides* of Kenya was developed by using characters of the genitalia, especially the morphology of the aedeagus and parameres. Genitalic characters of males are more useful in delineating subgenera, as opposed to the morphology of females, which often shows numerous similarities crossing subgeneric lines (i.e., antennal sensillae and wing patterns).

The subgenus *Remmia* was proposed by Glukhova (1977) for the members of the *schultzei* group in which there is a marked reduction in the radial cells of the wing; however, this reduction in venation is seen in other ceratopogonid genera and is therefore not considered a valid basis for proposing a new subgenus. Five of the group names proposed by Khamala & Kettle (1971) have been transferred to subgenera; i.e., the *fulvithorax* group to the subgenus *Triethecoides*, the *cornutus* group to the subgenus *Monoculicoides*, the *nivosus* group to the subgenus *Beltranmyia*, the *distinctipennis* group to the subgenus *Meijerehelea*, and the *magnus* group to the subgenus *Culicoides* s. str. Other group names have been changed or rejected, and the *pallidipennis* group (= *imicola* group) and most species in the *adersi*, *shimoniensis*, and *stercorarius* groups have been left unplaced. The 55 known species of Kenyan *Culicoides* have been arranged in five recognized subgenera and eight species groups; nine species are unplaced (Appendix). Males of 46 of the 55 species are known. Although the species groups used here are indicative of their probable future subgeneric status, new subgenera cannot be proposed (or subgeneric names from other regions cannot be used) until their affinities with the *Culicoides* fauna of other areas, as well as within the Afrotropical Region, have been established.

Several species have been transferred from one group to another as necessary. These include: *sylvicola* Khamala & Kettle from the *milnei* group to the subgenus *Culicoides*, *pynostictus* Ingram & Macfie from the *distinctipennis* group to the subgenus *Beltranmyia* (on the basis of spermathecal shape and number of sensilla per antennal segment), *fuscicaudae* Macfie (= *ravus* De Meillon) from the *inornatipennis* group to the *similis* group (on the basis of the male genitalia), *parvulus* Khamala & Kettle from the *stercorarius* group to the *similis* group (based on wing pattern and antennal sensory pattern), and *kaimosiensis* Khamala & Kettle from the *dekeyseri* group and *eridodendroni* Carter, Ingram & Macfie from the *neavei* group to unplaced species.

The species of the *imicola* and *schultzei* groups have been the most difficult to assess. Although *grahamii* Austen has been commonly reported from the Afrotropical Region, Khamala & Kettle's specimens of *grahamii* apparently represent an undescribed species because the combination of characters used in their description fit neither *grahamii* nor the closely related *glabripennis* Goetghebuer. M. Cornet (personal communication) has not been able to identify specimens of either of these two

species from Kenya material submitted to him by A. Walker. Khamala & Kettle (1971) incorrectly identified their *schultzei* (Enderlein) material as *kingi* Austen, and their material identified as *schultzei* apparently is an undescribed species (presented herein as sp. 4).

### Materials and Methods

This review of the systematics of *Culicoides* of Kenya was initiated in 1981 as a research project of the Virology Division, U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, Md. The purpose of this study is to elucidate the taxonomic status of *Culicoides* species groups of the eastern Afrotropical Region that might be involved in the epidemiology of Rift Valley fever.

A comprehensive review of all collection records in the published literature and of all African *Culicoides* contained in the collections of the Department of Entomology, National Museum of Natural History, Washington, D.C., was done to develop a provisional list of the *Culicoides* known to occur within Kenya. Especially helpful was the East African study of Khamala & Kettle (1971), the list of Ceratopogonidae in the "Catalogue of the Diptera of the Afrotropical Region" (Wirth et al. 1980), and collections made by A. Walker while in Kenya (M. Cornet, personal communication). The original descriptions of all species were obtained to determine nomenclatural synonymies and the location of type depositories.

The collection of the National Museum of Natural History provided a wealth of material from Kenya and neighboring countries and more distant areas of the Afrotropical Region. It includes extensive series from Ethiopia, Gambia, Nigeria, Republic of South Africa, Zaire, and Zimbabwe. Paratypes of nine of Khamala & Kettle's described species also were represented in the museum's collections. Additional material was obtained from the Institute of Parasitology, Strasbourg; the Museum of Natural History, Paris; the Center for Faunistic Studies, Bondy; and the Animal Virus Research Institute, Pirbright. Richard Lane of the British Museum (Natural History), London, assisted with the loan of type specimens and other material. Other types necessary for study were borrowed whenever possible from their respective depositories. During this study, Michel Cornet, Office de la Recherche Scientifique et Technique Outre-Mer, Bondy and Dakar, provided invaluable systematic information and specimens of the *Culicoides* fauna of Kenya and the surrounding Ethiopian region, including important notes and specimens of the *schultzei* group. During 1981 and 1982, extensive light trap collections were made in several areas of Kenya by U.S. Army entomologists while carrying out surveys of Rift Valley fever virus in mosquitoes. At the same time, collections of the shells of the giant African snail yielded a valuable series of an

unusual species of *Culicoides* in the taxonomically difficult *nigripennis* group. Through these loans and collections, the number of *Culicoides* confirmed for Kenya now includes 55 species. Those members of the *schultzei* group identified herein as species 4, 5, and 6 will be published at a future date by M. Cornet.

The bionomics and medical importance of the *Culicoides* of Kenya have been dealt with on a species-by-species basis. Emphasis is placed on providing workable keys for the identification of males and females and complete systematic discussions of each species, including line drawing illustrations. All drawings were made from slide-mounted specimens and illustrate the following morphological characters: female wing pattern, antenna and maxillary palpus with distribution of sensilla, mandible, eye separation, femora and tibiae of fore-, mid-, and hindlegs (including hindtibial comb), spermathecae, male genitalia (parameres shown separately), and aedeagal variation when necessary for identification.

The taxonomic treatment of each species includes a section listing all known nominal taxa, references, type data, and depositories. Following these synonymic entries is a diagnosis of the species using primary diagnostic characters for females and males, and a complete taxonomic description, including the female head, thorax, legs, wing, abdomen, and male genitalia. The discussion section includes remarks on synonymic problems, subgeneric or group placement, status and notes on type material, previous misidentifications, etc., and gives salient characters for use in differentiating closely related species. A further section covers the bionomics of the species, including citations of the descriptions of immature stages, larval habitats, rearing records, adult seasonal and ecological distribution, and host preferences and biting habits of adults. The medical importance of the species is noted, particularly in relation to virus isolations. The final sections cover the confirmed distribution of the species by country and all material examined, including the types.

The following acronyms are used for cited type depositories: Animal Virus Research Institute, Pirbright, England (AVRI); British Museum (Natural History), London, England (BMNH); South African Institute of Medical Research, Johannesburg, South Africa (IMRJ); Institut Pasteur, Algiers, Algeria (IPA); Institut de Parasitologie et Pathologie Tropicale, Faculté de Médecine, Université Louis Pasteur, Strasbourg, France (IPS); Muséum National d'Histoire Naturelle, Paris, France (MHN); Musée Royal de l'Afrique Centrale, Tervuren, Belgium (MRAC); Museum National Hongrois, Budapest, Hungary (NMH); National Museum, Nairobi, Kenya (NMK); Office de la Recherche Scientifique et Technique d'Outre-Mer, Bondy, France (ORSB); Presidency College, University of Calcutta, India (PCC); U.S. National Museum of Natural History, Smithsonian Institution, Wash-

ington, D.C. (USNM); and Veterinary Research Institute, Onderstepoort, South Africa (VRIO).

All light trap and reared material was slide-mounted in phenol-balsam using the method of Wirth & Marston (1968). Pinned material was slide-mounted using the method of Boesel (1977). For a complete explanation of the general morphology and terminology of the *Culicoides*, see Wirth (1952). The taxonomic descriptions follow the general format used by Wirth & Blanton (1959). All measurements were made from slide-mounted specimens with a calibrated ocular micrometer.

The following measurements are used in the taxonomic descriptions: The wing length is measured from the basal arculus to the wing tip; the costal ratio is obtained by dividing the length of the costa by the wing length. The antennal ratio (A.R.) is determined by the combined lengths of the five distal flagellar segments divided by the combined lengths of the preceding eight (proportions given for flagellar segments refer to relative lengths and should not be regarded as absolute measurements). The proboscis/head ratio (P/H) is obtained by dividing the distance from the tormae to the end of the labrum-epipharynx by the distance from the tormae to the interocular setal base. The palpal ratio (P.R.) is obtained by dividing the length of the third palpal segment by its greatest width. Variation is expressed by the mean, the range (minimum-maximum values), and the sample size (*n*).

#### Key to the Subgenera, Groups, and Species of the *Culicoides* of Kenya

##### Females

1. Abdomen with 3 functional spermathecae ..... 2
- Abdomen with 1 or 2 functional spermathecae ..... 3
- 2(1). Spermathecae elongate-ovoid or saccate with broad, unsclerotized ducts; wing with distinct pale spots over r-m cross-vein and on anterior margin over distal ½ of 2nd radial cell, other pale areas less distinct; scutum and upper pleuron of thorax yellowish; 3rd segment of maxillary palpus with sensilla scattered on distal surface; eyes broadly contiguous; antenna with sensilla coeloconica on segments 3, 11-15 (subgenus *Trithecoides*) ..... *fulvithorax* (Austen)
- Spermathecae ovoid with very long, curved, sclerotized necks; wing without pale spots; thorax pale brown; 3rd segment of maxillary palpus with a single large, deep sensory pit; eyes very narrowly separated; antenna with sensilla coeloconica on segments 3-14 (unplaced) ..... *walkeri* Boorman

- 3(1). One functional spermatheca present, rudimentary spermatheca absent . . . . 4  
Two functional spermathecae and a rudimentary 3rd present . . . . . 9
- 4(3). Wing elongate, broadest before middle (basal  $\frac{1}{3}$ ); wing pattern of irregular pale spots and streaks; antenna with sensilla coeloconica on segments 3, 8-10; spermatheca elongate, distally expanded (subgenus *Monoculicoides*) . . . . . *cornutus* De Meillon  
Wing not elongate, broadest at or beyond middle; wing pattern of distinct, rounded pale spots; antenna with sensilla coeloconica on segments 3-14 or 3-15; spermathecal shape various . . . 5
- 5(4). Spermatheca ovoid; antenna with sensilla coeloconica on segments 3-14 (subgenus *Beltranmyia*) . . . . . 6  
Spermatheca sagittate or elongate-ovoid; antenna with sensilla coeloconica on segments 3-14 or 3-15 (subgenus *Meijerehelea*) . . . . . 7
- 6(5). Wing pattern of large, prominent pale spots between veins, often confluent; pale spot over r-m crossvein very large, extending caudally into cell M2 and base of cell M1; cell R5 with 2 large pale spots in addition to spot over r-m crossvein; eyes broadly separated. . . . . *nivosus* De Meillon  
Wing with pale spots smaller and more restricted, not confluent; pale spot over r-m crossvein small and narrow, not extending caudally into cells M1 and M2; cell R5 with 4 pale spots; eyes very narrowly separated . . . . .  
. . . . . *pyncostictus* Ingram & Macfie
- 7(5). Spermatheca elongate-ovoid; antenna with sensilla coeloconica on segments 3-14; wing with 3 pale spots in cell R5 . . . . . *isechnoensis* Glick, n. sp.  
Spermatheca sagittate in shape, distal portion weakly sclerotized; antenna with sensilla coeloconica on segments 3-15; wing with 3 or 4 pale spots in cell R5 . . . . . 8
- 8(7). Wing with 3 pale spots in cell R5, pale spot absent from just below and distal to transverse pale spot on anterior wing margin . . . . . *distinctipennis* Austen  
Wing with 4 pale spots in cell R5, pale spot present just below and distal to transverse pale spot on anterior wing margin (this spot often greatly reduced) . . . . . *leucostictus* Kieffer
- 9(3). Wing with 1st and 2nd radial cells absent; prominent pattern of pale spots present; antenna with sensilla coeloconica on segments 3, 8-10 (*schultzei* group) . . . . . 10
- Wing with radial cells present; wing pattern and antennal sensory pattern various . . . . . 14
- 10(9). Wing with 1 pale spot in cell M4 . . . . 11  
Wing with 2 pale spots in cell M4 . . . . 13
- 11(10). Pale spot in cell M4 transverse, extending from vein M3+4 to posterior wing margin, sometimes with mesal constriction, entirely divided, or reduced; apices of veins M1, M2, M3+4, and Cul pale . . . . . sp. 6  
Pale spot in cell M4 more ovoid, not extending entire length of cell; apices of veins pale or dark . . . . . 12
- 12(11). Pale spot in anterior portion of cell M4 proximal to vein M3+4, not extending to posterior wing margin; apices of veins M1, M2, M3+4, and Cul prominently pale . . . . . sp. 4  
Pale spot in cell M4 distal, proximal to wing margin; apices of veins dark . . . . . sp. 5
- 13(10). Pale spots in cell M4 separate, 1 in anterior portion and proximal to vein M3+4, the other in distal portion of cell and proximal to wing margin; moderately large, elongated pale areas above and below vein M2; 3rd segment of maxillary palpus very broad distally, P.R. 1.82-2.0; distal antennal segments not greatly elongated, ratio of segment 11 to 10 less than 1.45, A.R. 0.97-1.03; costa short, costal ratio 0.50-0.51 . . . . . *schultzei* (Enderlein)  
Pale spots in cell M4 often coalescing into a large, elongated pale spot with a moderate mesal constriction; pale spot above middle of vein M2 reduced, ovoid, spot below vein short and narrow; 3rd segment of maxillary palpus moderately broadened distally, P.R. 2.18-2.53; distal antennal segments elongate, ratio of segment 11 to 10 1.5 or greater, A.R. 1.09-1.12; costa longer, costal ratio 0.55-0.56 . . . . . *rhizophorensis* Khamala & Kettle
- 14(9). Second radial cell with distal portion pale; antenna with sensilla coeloconica usually on segments 3, 11-15; eyes usually contiguous . . . . . 15  
Second radial cell dark to apex (distal portion of vein Rs may be pale); antennal sensory pattern and eye separation various . . . . . 29
- 15(14). Third segment of maxillary palpus with sensilla distributed in more than 1 sensory pit (usually scattered in many small, shallow pits) . . . . . 16  
Third segment of maxillary palpus with sensilla confined to a single sensory pit . . . . . 25



- 16(15). Wing with a separate dark spot in middle of cell M4, surrounded by a pale ring (subgenus *Culicoides* s. str.) ... 17  
Wing without a separate dark spot in middle of cell M4 (*milnei* group) ... 19
- 17(16). Third segment of maxillary palpus with 1 moderately large, shallow sensory pit and a 2nd smaller one; apices of veins M1 and M2 dark; proboscis short, P/H 0.68 *sylicola* Khamala & Kettle  
Third segment of maxillary palpus with sensilla scattered in many small, shallow sensory pits; apices of veins M1 and M2 pale; proboscis longer, P/H 0.80-0.88 ... 18
- 18(17). Antenna with sensilla coeloconica on segments 3, 11-15; antennal segments brown; wing with large, broad pale spot near apex of cell R5; hindtibial comb with 5 spines ... *brucei* Austen  
Antenna with sensilla coeloconica on segments 3, 7, 9, 11-15; proximal 8 antennal segments yellowish; wing with pale spot in distal portion of cell R5 subapical, transverse; hindtibial comb with 6 spines ... *magnus* Colaco
- 19(16). Apices of wing veins M1 and M2 prominently pale; cell M4 with 2 pale spots ... *moreli* Clastrier  
Apices of veins dark (at least vein M2), pale band may be present at wing apex; cell M4 with 1 pale spot ... 20
- 20(19). Wing base dark, with several isolated pale spots ... *krameri* Clastrier  
Wing base broadly pale ... 21
- 21(20). Very large species, wing length 2.13-2.45 mm; 3rd segment of maxillary palpus with sensilla distributed in 1 large and 1 small sensory pit ... *giganteus* Khamala & Kettle  
Smaller species, wing length usually less than 1.8 mm (1.25-1.81 mm); distribution of sensilla on 3rd segment of maxillary palpus various ... 22
- 22(21). Mesonotum yellowish; wing with extensive pale markings, very large pale spots over r-m crossvein and most of 2nd radial cell, 1 large rectangular pale spot over middle of vein M2; hindtibial comb with 6 spines ... *kerichoensis* Khamala & Kettle  
Mesonotum dark brown; wing with most pale spots smaller and more restricted, vein M2 with small, rounded pale spots above and below middle; hindtibial comb with 5 spines ... 23
- 23(22). Third segment of maxillary palpus with single large, well-defined sensory pit, occasionally with 1 or 2 smaller, shallow pits; wing with distinct pale band at apex ... *isoloensis* Cornet, Nevill & Walker
- Third segment of maxillary palpus with sensilla distributed in several to numerous sensory pits; apex of wing dark (occasionally with a narrow yellowish band in *zuluensis*) ... 24
- 24(23). Pale spot over r-m crossvein very large and quadrangular, extending broadly to costal margin; eyes contiguous for a distance equal to length of about 1.5 ocular facets ... *zuluensis* De Meillon  
Pale spot over r-m crossvein smaller, extending to costal margin, narrowed over radial vein; eyes narrowly separated ... *milnei* Austen
- 25(15). Eyes very narrowly separated, almost contiguous; hindtibial comb with 4 spines; wing with large pale spots over r-m crossvein and just distad of 2nd radial cell; prominent broad pale bands over most of veins M1 and M2 to apices (*albovenosus* group) ... *albovenosus* Khamala & Kettle  
Eyes contiguous for a distance equal to length of 1-2 ocular facets; hindtibial comb with 5 spines; wing pattern various, distal portion of cell R5 with a large, usually distinct pale area (*imicola* group, in part) ... 26
- 26(25). Wing with prominent pale spots only over r-m crossvein and distal portion of 2nd radial cell, remaining pale spots ill-defined, particularly in distal 1/3 of wing ... *kibatiensis* Goetghebuer  
Entire wing with extensive, prominent pale markings ... 27
- 27(26). Apex of wing without macrotrichia or with only a few present; 1st spine of hindtibial comb (that closest to tibial spur) large, very long and stout relative to other 4 spines ... *trifasciellus* Goetghebuer  
Apex of wing with macrotrichia more numerous, especially in cell R5; 1st spine of hindtibial comb normal, not unusually long or stout relative to other spines ... 28
- 28(27). Pale spots in cell M1 forming 2 separate, distinct, dark gray areas bordering on vein M2, the 1st at middle of cell and 2nd at apex; 3rd segment of maxillary palpus with shallow sensory pit; antenna with sensilla coeloconica on segments 3, 12-15 ... *imicola* Kieffer  
Cell M1 paler, the dark areas bordering the veins reduced, with only 1 distinct gray area at midlength; 3rd segment of maxillary palpus with moderately deep sensory pit; antenna with sensilla coeloconica on segments 3, 11-15 ... *pseudopallidipennis* Clastrier
- 29(14). Wing without pale spots, area around radial cells may be vaguely pale ... 30

- Wing with pale spots present, although they may be very weak ..... 31
- 30(29). Eyes very narrowly separated by a distance equal to length of about  $\frac{1}{2}$  an ocular facet; antenna with sensilla coeloconica on segments 3–10; scutellum dark brown; legs brown with distinct pale bands on femora and tibiae (*similis* group) ..... *ravus* De Meillon
- Eyes widely separated by a distance equal to length of about 3 ocular facets; antenna with sensilla coeloconica on segments 3, 11–14; scutellum yellowish brown; legs pale grayish brown, femora and tibiae without distinct pale bands (*inornatipennis* group) ..... *nairobiensis* Glick, n. sp.
- 31(29). Eyes contiguous; antenna with sensilla coeloconica on segments 3, 11–15; wing with pale spots very inconspicuous to prominent (*imicola* group, in part) ..... 32
- Eyes separate; antennal sensory pattern various, often with sensilla coeloconica present on some or all proximal segments; wing pattern various ..... 33
- 32(31). Wing with only 2 very weak pale spots, over r-m crossvein and on anterior margin just distad of 2nd radial cell; legs without prominent pale bands; eyes with short interfacetal setae ..... *kanagai* Khamala & Kettle
- Wing with extensive pattern of moderately distinct pale markings, including 3 pale spots in cell R5 and 3 pale spots in cell M1 (larger basal 2 in cell M1 may coalesce); legs with prominent pale bands; eyes without interfacetal setae ..... *gulbenkiani* Caeiro
- 33(31). Pale spot not located over r-m crossvein but lying just distad of vein in base of cell R5 (*similis* group, in part) ..... 34
- Wing with pale spot over r-m crossvein ..... 39
- 34(33). Wing without prominent pattern, only 3 weak pale areas present, including a narrow pale area proximal to radial cells extending from just distad of r-m crossvein to apex of costa, an indistinct pale spot in cell M4, and an indistinct pale area in distal portion of anal cell; eyes moderately separated by a distance equal to length of 1 ocular facet; antenna with sensilla coeloconica on segments 3, 7–10 ..... *micheli* Cornet & Chateau
- Wing with prominent pattern of pale spots; eye separation and antennal sensory pattern various ..... 35
- 35(34). Wing with small pale spot just past middle of basal cell; prominent, rounded pale spots present over middle of veins M1 and M2; eyes narrowly separated by a distance equal to length of  $\frac{1}{2}$  an ocular facet; antenna with sensilla coeloconica on segments 3, 5, 7, 9, 11–14 ..... *radiomaculatus* Khamala & Kettle
- Wing without a small pale spot in basal cell, without rounded pale spots over middle of veins M1 and M2; eyes very narrowly separated by a distance equal to less than  $\frac{1}{2}$  an ocular facet; antennal sensory pattern various ..... 36
- 36(35). Wing without prominent pale spots in distal portion of cells R5, M1, and M2; pale spots in distal portions of cell M4 and anal cell ill-defined; antenna with sensilla coeloconica on segments 3, 10, 12, 14 ..... *parvulus* Khamala & Kettle
- Wing with prominent pale spots in distal portion of cells R5, M1, M2, M4, and anal cell; antenna with sensilla coeloconica on segments 3–10 or 3, 7–10 ..... 37
- 37(36). Antenna with sensilla coeloconica on segments 3–10; wing with pale streaks situated just above and below middle of vein M2 ..... *expectator* Clastrier
- Antenna with sensilla coeloconica on segments 3, 7–10; wing without pale streaks above and below middle of vein M2 ..... 38
- 38(37). Wing with a distinct, elongate pale spot near base of cell M1; proximal antennal segments moderately elongated, A.R. 1.06–1.18; mandible with 13–14 teeth ..... *accraensis* Carter, Ingram & Macfie
- Wing with only a very narrow, weak pale streak in basal portion of cell M1; proximal antennal segments short, A.R. 1.31–1.44; mandible with 9–10 very minute teeth ..... *karenensis* Glick, n. sp.
- 39(33). Distal antennal segments (11–15) without sensilla coeloconica; wing with prominent pattern of pale spots (*similis* group, in part) ..... 40
- Some or all of distal antennal segments with sensilla coeloconica; wing pattern various ..... 43
- 40(39). Wing with an extra pale spot present in cell R5, below pale spot on anterior margin just distad of 2nd radial cell ..... 41
- Wing without an extra pale spot in cell R5 ..... 42
- 41(40). Pale spot on anterior margin of cell R5 small, not extending caudally much below 2nd radial cell; extra pale spot in cell R5 situated well above vein M1; antenna with sensilla coeloconica on segments 3, 5, 7–10 ..... *similis* Carter, Ingram & Macfie
- Pale spot on anterior margin of cell R5 larger, transverse, extending caudally well below 2nd radial cell; extra pale spot in cell R5 lower, situated proxi-

- mal to vein M1; antenna with sensilla coeloconica on segments 3-10 .....  
 ..... *tropicalis* Kieffer
- 42(40). Wing with prominent pale streaks over distal  $\frac{1}{2}$  of vein M1 and distal portion of vein M2; pale spots in distal portion of cells R5, M1, and M2 distinct, extending to wing margin; proximal antennal segments short, A.R. 1.10-1.32; 3rd segment of maxillary palpus short and greatly expanded, P.R. 1.73-1.92 .....  
 ..... *kobae* Cornet & Chateau
- Wing without prominent pale streaks over veins M1 and M2; pale spots in distal portion of cells R5, M1, and M2 ill-defined, not extending to wing margin; proximal antennal segments moderately elongated, A.R. 0.93-1.00; 3rd segment of maxillary palpus longer, expanded at midlength, P.R. 2.23-2.32 .....  
 ..... *pretoriensis* Kramer & Nevill
- 43(39). Wing pattern conspicuous, including distinct pale spots in distal portion of cells R5, M1, M2, M4, and anal cell 44
- Wing with distinct pale spots over r-m crossvein and on anterior margin just distad of 2nd radial cell, other distal pale spots indistinct or absent ..... 47
- 44(43). Wing with pale spots greatly enlarged and confluent; 3rd segment of maxillary palpus with sensilla scattered singly on distal surface in small, shallow pits; antenna with sensilla coeloconica on segments 3, 11-14; hindtibial comb with 6 spines (unplaced) .....  
 ..... *adersi* Ingram & Macfie
- Wing with pale spots smaller and well defined, not confluent; 3rd segment of maxillary palpus with a single, large, rounded sensory pit; antennal sensory pattern various; hindtibial comb with 4 spines ..... 45
- 45(44). Pale spot over r-m crossvein extending caudally into cell M2, coalescing with a narrow pale streak running through basal  $\frac{1}{2}$  of cell; wing without a distinct, separate pale spot below median fork; antenna with sensilla coeloconica on segments 3, 7, 9, 11, 13-14 (unplaced) .....  
 ..... *coarctatus* Clastrier & Wirth
- Pale spot over r-m crossvein not extending caudally into cell M2; wing with a distinct, separate pale spot just below median fork in cell M2; antenna with sensilla coeloconica on segments 3, 11-14 or 3, 10-14 (*C. neavei* group) .. 46
- 46(45). Pale spot on anterior margin just distad of 2nd radial cell small and rounded, not extending caudally much below radial cell; distal pale spots in cells M1 and M2 extending to wing margin; antenna with sensilla coeloconica on segments 3, 11-14 .....  
 ..... *ovalis* Khamala & Kettle
- Pale spot on anterior margin of wing larger, transverse, extending caudally well below 2nd radial cell; distal pale spots in cells M1 and M2 not extending to wing margin; antenna with sensilla coeloconica on segments 3, 10-14 ..  
 ..... *neavei* Austen
- 47(43). Wing with only 2 small pale spots present, over r-m crossvein and on anterior margin just distad of 2nd radial cell 48
- Wing with more than 2 anterior pale spots present (unplaced) ..... 49
- 48(47). Antenna with sensilla coeloconica on segments 3-15; distal antennal segments not greatly elongated, A.R. 1.21-1.25; spermathecae ovoid, with short, tapering necks; mandible with 12-14 teeth; hindtibial comb with 4 spines, that nearest spur longest (unplaced) ... *gambiae* Clastrier & Wirth
- Antenna with sensilla coeloconica on segments 3, 5, 7, 9, 11-15; distal antennal segments greatly elongated, A.R. 1.44-1.64; spermathecae subspherical, with long, narrow, tapering necks; mandible with 18-22 teeth; hindtibial comb with 4 spines, the 2nd from spur longest (*nigripennis* group) ..... sp. 7
- 49(47). Wing with pale spot over r-m crossvein not extending to costal margin; very weak, almost inapparent pale spots present in distal portions of cells R5, M1, and M2; weak distal pale spots in cell M4 and anal cell; antenna with sensilla coeloconica on segments 3, 11-15 *eriodendroni* Carter, Ingram & Macfie
- Wing with pale spot over r-m crossvein extending anteriorly to costal margin; without distal pale spots in cells R5, M1, and M2; other pale spots and antennal sensory pattern various ..... 50
- 50(49). Wing with weak pale spot in base of cell M1, weak pale spot in cell M2 below median fork coalescing with another above base of vein M3+4, and weak pale spots in distal portions of cell M4 and anal cell; antenna with sensilla coeloconica on segments 3-15 .....  
 ..... *bedfordi* Ingram & Macfie
- Wing without pale spot in cell M2 proximal to median fork; basal  $\frac{1}{2}$  of cell M2 diffusely pale; weak pale spots present in distal portion of cell M4 and anal cell; antennal sensory pattern various ..... 51
- 51(50). Medium-sized species, wing length 0.99 mm; antenna with sensilla coeloconica on segments 3, 11-15; distal antennal



- sides of median process without long, pointed processes ..... *papillatus* Khamala & Kettle
- Apex of median distal process without papillae; sides of median process with pair of long, slender, pointed processes ..... 12
- 12(11). Median distal process of aedeagus short and very broad; ventral root of basistyle with short anterior lobe; wing with prominent pattern of pale spots ..... *kobae* Cornet & Chateau
- Median distal process of aedeagus long and only moderately stout; anterior lobe of ventral root very long; wing without prominent pattern, pale spots restricted to area proximal to r-m crossvein, radial cells, and distal portions of cell M4 and anal cell ..... *micheli* Cornet & Chateau
- 13(3). 9th tergum without apicolateral processes ..... 14
- 9th tergum bearing apicolateral processes ..... 21
- 14(13). Ventral root of basistyle very long, tapering to a point (*imicola* group, in part) ..... 15
- Ventral root of basistyle absent (*milnei* group, in part) ..... 18
- 15(14). Ventral membrane of 9th sternum spiculate ..... 16
- Ventral membrane of 9th sternum without spicules ..... 17
- 16(15). Apex of paramere with minute setae; hindtibial comb with spine nearest spur very long and stout relative to other 4 spines ..... *trifasciellus* Goetghebuer
- Apex of paramere bare; 1st spine of hindtibial comb normal, not greatly elongated or stout relative to other spines ..... *imicola* Kieffer
- 17(15). Distal median process of aedeagus short and slender; subapical, anteriorly directed process of aedeagus very long with rounded apex; wing with 2 pale spots in cell R5, excluding the pale spot over r-m crossvein ..... *kibatiensis* Goetghebuer
- Distal median process of aedeagus long and very stout; subapical process short, with jagged apex; wing with 3 pale spots in cell R5, excluding the pale spot over r-m crossvein *gulbenkiani* Caeiro
- 18(14). Aedeagus with short, anteriorly directed subapical process arising from near base of median process ..... 19
- Aedeagus without subapical process .. 20
- 19(18). Wing base extensively pale, with broad pale band extending from costal margin caudally into anal cell ..... *milnei* Austen
- Wing base dark, with several isolated pale spots ..... *krameri* Clastrier
- 20(18). Wing with very large, quadrangular pale spot over r-m crossvein, extending broadly to costal margin; apex of wing with narrow pale band, extending from distal pale spot in cell R5 to just above vein M2; hindtibial comb with 5 spines ..... *zuluensis* De Meillon
- Wing with pale spot over r-m crossvein smaller, with slight constriction over the radial vein; apex of wing without pale band, apices of veins M1 and M2 pale; hindtibial comb with 6 spines ..... *moreli* Clastrier
- 21(13). Apicolateral processes short and very broad, triangular (*imicola* group, in part) ..... 22
- Apicolateral processes short to long, slender or stout, not broadly triangular 23
- 22(21). Aedeagus with moderately long, anteriorly directed, subapical process arising from near base of median distal process .. *pseudopallidipennis* Clastrier
- Aedeagus with very long, slender, posteriorly directed, pointed process arising from above base of median distal process and extending well beyond caudal margin of 9th tergum ..... *spinifer* Khamala & Kettle
- 23(21). Apex of paramere setose ..... 24
- Apex of paramere bare ..... 33
- 24(23). Ventral root of basistyle with long, prominent, anteriorly and posteriorly directed lobes with pointed apices (unplaced) ..... *adersi* Ingram & Macfie
- Ventral root of basistyle without prominent anterior and posterior lobes .. 25
- 25(24). Lateral arms of aedeagus broadly connected from near bases by a less sclerotized membrane, basal arch shallow (*milnei* group, in part) ..... 26
- Lateral arms of aedeagus not connected by a sclerotized membrane, basal arch deep ..... 27
- 26(25). Inner margin of basistyle with row of short, stout spines; subapical, anteriorly directed process of aedeagus with rounded apex; a very large species, wing length of single known male 2.63 mm .... *giganteus* Khamala & Kettle
- Inner margin of basistyle with patch of short spines on mesal surface; subapical process of aedeagus with truncate, jagged apex; smaller species, wing length less than 2.0 mm ..... *kerichoensis* Khamala & Kettle
- 27(25). Inner margin of basistyle with patch of short spines on mesal surface; apicolateral processes short, directed mesal-

- ly; paramere without prominent basal knob; wing with large pale spot in cell M4 and smaller dark spot in middle, forming a pale ring (subgenus *Culicoides* s. str.) ..... 28
- Inner margin of basistyle without spines; apicolateral processes longer, divergent; paramere with prominent basal knob; wing without pale ring in cell M4 (*schultzei* group) ..... 29
- 28(27). Apicolateral processes slender, closely approximated; distal median process of aedeagus slender; ventral root of basistyle very short; wing with subapical, transverse pale spot in cell R5; hindtibial comb with 6 spines ..... *magnus* Colaco
- Apicolateral processes stouter, widely spaced; distal median process stout; ventral root of basistyle prominent, stout, tapering to a mesally directed, pointed apex; wing with large, broad pale spot in distal portion of cell R5, nearly reaching apex; hindtibial comb with 5 spines ..... *brucei* Austen
- 29(27). Apicolateral processes very long, broad basally, very closely approximated, curving laterally from bases; lateral arms of aedeagus very stout distally, sides of aedeagus tapering to very broad, truncate apex; wing with 2 pale spots in cell M4; antennal segment 11 without a sensillum trichodeum ..... *schultzei* (Enderlein)
- Apicolateral processes shorter, not closely approximated, directed more posteriorly; lateral arms of aedeagus more slender; wing with 1 or 2 pale spots in cell M4; antennal segment 11 with a short sensillum trichodeum ..... 30
- 30(29). Antennal segments 7 and 9 each with 2 long and 1 short sensilla trichodea; wing with 1 pale spot in distal portion of cell M4, proximal to posterior margin of wing ..... n. sp. 5
- Antennal segments 7 and 9 each with 1 long and 1 short sensilla trichodea; wing with 1 or 2 pale spots in cell M4 ..... 31
- 31(30). Dististyle entirely covered with setae to apex; apicolateral processes slender, very widely separated; wing with 2 pale spots in cell M4 ..... *rhizophorensis* Khamala & Kettle
- Dististyle with setae over basal  $\frac{1}{2}$  to  $\frac{2}{3}$ ; apicolateral processes larger and stouter, not as widely separated; wing usually with 1 pale spot in cell M4 ... 32
- 32(31). Pale spot only in anterior portion of cell M4, proximal to vein M3+4 .. n. sp. 4
- Pale spot in cell M4 extending proximally from vein M3+4 to posterior wing margin, sometimes with a mesal constriction or reduced ..... n. sp. 6
- 33(23). Ventral root of basistyle very short or absent ..... 34
- Ventral root of basistyle long and slender ..... 39
- 34(33). Ventral root of basistyle very short (subgenus *Meijerehelea*) ..... 35
- Ventral root absent ..... 36
- 35(34). Main stem of paramere short and stout, greatly expanded distally, abruptly tapering near apex; wing cell R5 with 3 pale spots, pale spot absent from just below and distal to large pale spot on anterior wing margin ..... *distinctipennis* Austen
- Main stem of paramere longer, stout basally, tapering distally to apex; wing cell R5 with 4 pale spots, including a small pale spot just below and distal to large pale spot on anterior wing margin ..... *leucostictus* Kieffer
- 36(34). Paramere with large basal knob, elongated anteriorly into a slender process (subgenus *Beltranmyia*) ..... 37
- Paramere with basal knob simple or absent ..... 38
- 37(36). Distal median process of aedeagus short and broad, with rounded apex; ventral membrane of 9th sternum spiculate; wing with very large, confluent pale spots filling most of cells ..... *nivosus* De Meillon
- Distal median process of aedeagus broad basally, tapering to a very slender, rounded apex; ventral membrane of 9th sternum without spicules; wing with pale spots smaller, not confluent ..... *pyncostictus* Ingram & Macfie
- 38(36). Paramere with stout, simple basal knob, stem stout over basal  $\frac{1}{2}$ , tapering distally; distal median process of aedeagus stout with truncate apex; apicolateral processes of 9th tergum stout (*albovenosus* group) ..... *albovenosus* Khamala & Kettle
- Paramere without basal knob, moderately slender throughout, slightly tapering distally to apex; distal median process broad basally, tapering to a slender, rounded apex; apicolateral processes of 9th tergum long and slender (subgenus *Trithecoides*) ..... *fulvithorax* (Austen)
- 39(33). Wing with only 2 pale spots, over r-m crossvein and on anterior margin just distad of 2nd radial cell ..... 40
- Wing with more than 2 pale spots ... 41
- 40(39). Basal  $\frac{1}{2}$  of dististyle greatly enlarged, bulbous, covered with very long, spi-

- nose setae; inner margin of basistyle with large subbasal lobe; distal median process of aedeagus moderately short and slender with rounded apex; paramere with angulate, anteriorly directed basal knob (*nigripennis* group) ..... sp. 7
- Dististyle normal, not greatly enlarged at base, tapering gradually, without very long, spinose setae; inner margin of basistyle without subbasal lobe; distal median process of aedeagus stout, with truncate apex; knob of paramere laterally directed (unplaced) ..... *gambiae* Clastrier & Wirth
- 41(39). Wing without pale spots in distal portion of cells R5, M1, and M2; pale spots present in distal portions of cell M4 and anal cell (unplaced) ..... 42
- Wing with pale spots present in distal portions of all cells ..... 44
- 42(41). Ventral membrane of 9th sternum without spicules; wing with pale spot near base of cell M1, cell M2 pale at mid-length; distal median process of aedeagus moderately long and stout, tapering to a truncate apex ..... *bedfordi* Ingram & Macfie
- Ventral membrane of 9th sternum spiculate; wing without pale spots in cells M1 and M2; distal median process of aedeagus various ..... 43
- 43(42). Ventral membrane with numerous spicules; aedeagus with large, broad, distal median process; basal knob of paramere with short, anteriorly directed process, stem short and stout, tapering distally ..... *stercorarius* Khamala & Kettle
- Ventral membrane with only a few spicules present; aedeagus with a short, stout, distal median process; basal knob of paramere with long, slender, anteriorly directed process, stem longer and more slender ..... *kaimosiensis* Khamala & Kettle
- 44(41). Wing with pale spots diffuse, ill-defined; 9th sternum with shallow caudomedian emargination; basal knob of paramere stout, without anteriorly directed process (unplaced) ..... *shimoniensis* Khamala & Kettle
- Wing with prominent, well-defined pale spots; 9th sternum with deep caudomedian emargination; basal knob of paramere with short, stout, anteriorly directed process (*neavei* group) ... 45
- 45(44). Wing with pale spots in distal portion of cells M1 and M2 subapical, not extending to wing margin ..... *neavei* Austen
- Wing with pale spots in distal portion of

cells M1 and M2 extending to wing margin ..... *ovalis* Khamala & Kettle

### Genus *Culicoides* Latreille

*Culicoides* Latreille 1809: 251. Type species: *Culicoides punctatus* Latreille (by monotypy).

**Diagnosis.** Body moderately slender. Eyes usually bare. Antenna with 15 segments; female with proximal 8 segments short, rounded or oval, distal 5 segments more elongate; male antenna plumose, distal 3 segments elongate. Maxillary palpus with 5 segments; 3rd segment bearing a distal sensory pit or group of sensilla. Mesonotum concolorous or with a pattern; humeral pits large and distinct. Legs slender; femora without spines; tarsal claws small and equal, simple in female, divided at apices in male; empodium vestigial. Wings with dense microtrichia often forming pattern of light and dark markings; macrotrichia usually abundant, often confined to distal portion of wing; costa extending beyond middle of wing; 2 nearly equal radial cells present; median fork petiolate, base of M2 often interrupted. Female abdomen with 1 to 3 functional spermathecae. **Male Genitalia.** Ninth tergum usually with apicolateral processes; 9th sternum short, usually with caudomedian emargination; basistyle usually with distinct ventral and dorsal roots at base; dististyle usually slender and curved; aedeagus usually a Y-shaped structure, distal median process directed caudoventrally; parameres usually a pair of slender sclerites with knobbed bases and ventrally directed distal points, occasionally parameres partially or completely fused mesally.

### Subgenus *Beltranmyia* Vargas

*Culicoides*, subgenus *Beltranmyia* Vargas 1953: 34. Type species: *Culicoides crepuscularis* Malloch (original designation).

**Diagnosis.** Female eyes narrowly to broadly separated; without interfacetal setae. Female antenna with sensilla coeloconica usually on segments 3–15 or 3–14. Third segment of maxillary palpus with a single, distal sensory pit. Hindtibial comb with 4 spines. Wing pattern inconspicuous or of large, round to ovoid pale spots between the veins, pale spots may be confluent; 2nd radial cell dark to apex; macrotrichia usually abundant. Female abdomen with 1 ovoid to pyriform functional spermatheca. **Male Genitalia.** Ninth tergum with well-developed apicolateral processes; basistyle with ventral root short or absent, dorsal root short to moderately long; aedeagus with deep basal arch, distal median process with rounded apex; parameres usually separate, stem moderately slender, tapering to an abruptly bent, pointed apex.

**Kenya Species.** *C. nivosus* De Meillon, *C. pycnostictus* Ingram & Macfie.

***Culicoides (Beltranmyia) nivosus* De Meillon**  
(Fig. 1)

*Culicoides nivosus* De Meillon 1937: 341 (male, female, pupa). Holotype: ♂, Empangeni, Zululand, reared from pupa collected in an exposed pool of rainwater, 6-III-36. Paratypes: ♂♂, ♀♀, same locality as holotype and Inyoni, Mandini, and Blackburn, VII, VIII-36 (IMRJ).

*Culicoides circumscriptus* of Clastrier (1957: 415), not Kieffer (misident.).

**Diagnosis.** A moderately large, dark brown species. Female eyes moderately separated; sensilla coeloconica on antennal segments 3-14; 3rd segment of maxillary palpus with a large, deep sensory pit. Wing with a prominent pattern of large, rounded pale spots between the veins. Female abdomen with a large, ovoid spermatheca. **Male Genitalia.** Distal median process of aedeagus short and stout; stem of paramere slender, distally tapering.

**Female.** Wing length 1.20 mm (0.98-1.40 mm,  $n = 12$ ). **Head.** Dark brown. Eyes moderately separated by a distance slightly greater than the diameter of 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 19-13-13-13-14-14-14-15-21-21-23-28-36; A.R. 1.11 (1.01-1.18,  $n = 12$ ); sensilla coeloconica (with number per segment) on segments 3(5-6), 4(2-3), 5(2-3), 6(1-2), 7(2-3), 8(1-3), 9(1-3), 10(1-3), 11(1-2), 12(1-2), 13(1-2), 14(5-8). Third segment of maxillary palpus moderately expanded, with a large, rounded, deep sensory pit, P.R. 2.39 (2.21-2.68,  $n = 12$ ). Proboscis moderately long, P/H 0.85 (0.77-0.95,  $n = 12$ ); mandible with 13 teeth (11-15,  $n = 12$ ).

**Thorax.** Dark brown. Legs dark brown; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band; hindtibial comb with 4 spines, that nearest the spur longest. Halter infuscated pale brown, darkest at base of knob.

**Wing.** Macrotrichia long and abundant over entire wing. Wing pattern of large, prominent, rounded pale spots between the veins, often confluent; base of wing with a pale spot extending to anterior wing margin; a pale spot over r-m crossvein extending anteriorly to costal margin and caudally into cell M2; cell R5 with a pale spot on anterior wing margin just distad of 2nd radial cell, and a pale spot just past middle of cell; cell M1 with an elongate pale spot in middle of cell and a rounded spot near apex; cell M2 with a wide pale streak near base, often confluent with pale spots at base of wing and over r-m crossvein, an elongate pale spot in middle of cell, and a rounded pale spot at apex; cell M4 with a rounded pale spot filling almost entire cell; anal cell pale over basal  $\frac{1}{2}$ , and with a transverse pale spot in distal portion extending posteriorly to wing margin, usually with a distinct mesal constriction; veins M1, M2, M3+4, and Cu1 broadly pale-margined. Costal ratio 0.54 (0.51-0.57,  $n = 12$ ).

**Abdomen.** Dark brown. Spermatheca very dark brown, large, ovoid, without sclerotized neck, 0.094 by 0.062 mm (0.082-0.108 by 0.055-0.069 mm,  $n = 11$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, slender apicolateral processes; caudal margin with a short mesal cleft. Ninth sternum with a broad, deep caudomedian emargination; ventral membrane spiculate. Basistyle with ventral root absent, dorsal root moderately long and stout, distally tapering; dististyle nearly straight, moderately slender, tapering to a curved, pointed apex. Aedeagus with very deep basal arch; lateral arms slender, bases bent laterally; distal median process short and stout, tapering to a rounded apex. Parameres separate; basal portion of stem bent laterally, with a large basal knob, lateral margin elongated anteriorly; main stem moderately stout, tapering distally and slightly sinuate, distal portion curved laterally to a very slender, pointed apex.

**Discussion.** *Culicoides nivosus* can be distinguished easily from *pynostictus* Ingram & Macfie by the prominent wing pattern of large, rounded pale spots between the veins.

**Bionomics.** De Meillon (1937) described and illustrated the pupa, collected from an exposed pool of rainwater in Zululand; he reared adults from seepage pools at Salisbury, Zimbabwe (De Meillon 1942a). Nevill (1969) described and illustrated the fourth instar and pupa from South African material.

In Kenya (Khamala 1975, Lubega & Khamala 1976), *nivosus* was reared from a wide range of habitats at Lake Nakuru National Park, including mud and wet soil from the river edges, sand mixed with bird excreta on the edge of the lake, waterlogged mud with decaying vegetation in a *Cyperus* marsh, wet soil from edges of rainwater pools in *Hyperrhenia-Chloris* grasslands, waterlogged mud from a *Typha* swamp, wet soil from *Cynodon-Thameda* grassland fields, mud from edges of artificial drainage ditches, and decaying pieces of logs on the lake shore.

Dipeolu & Ogunrinade (1976) found *nivosus* emerging from boggy ground of a rocky hill site at Eruwa, Nigeria. In Zimbabwe, Braverman (1978) reported the main breeding site of *nivosus* to be around puddles rich in organic matter, but he also reared adults from mud taken from along streams and drainage canals with intermediate to very low content of organic matter. In the Salisbury area, it was second in abundance of species reared from mud samples at the edges of bodies of water; breeding continued throughout the year, except no specimens were collected in April and October, and adults were most abundant from November to February (wet season).

Khamala (1971) collected a few adults in East Africa from savannas in Kenya and Tanzania, and Walker (1976) collected *nivosus* in Kenya from high altitude forest and grasslands, moist *Combretum* woodland and grassland, semiarid *Acacia*



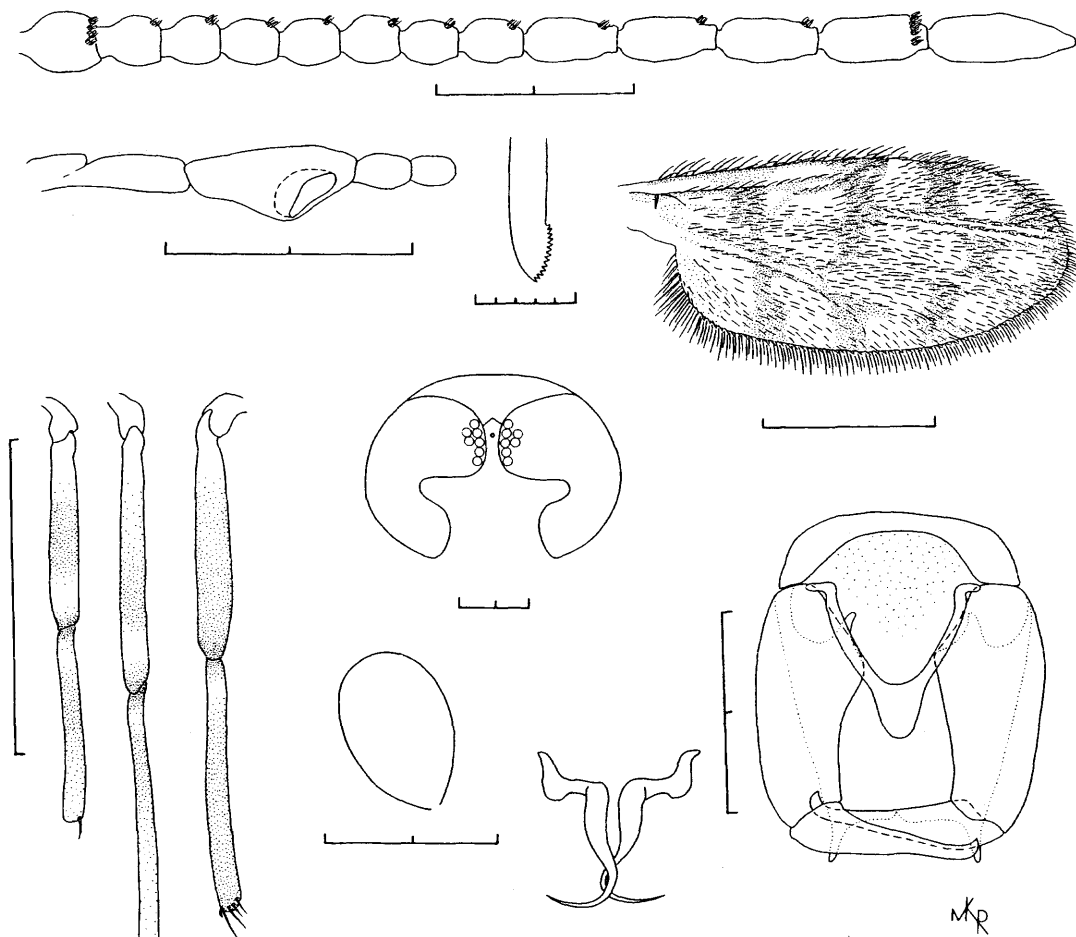


Fig. 1. *Culicoides* (*Beltranmyia*) *nivosus*. Adult female, male genitalia. (See key for scale.)

woodland and grassland, and arid *Acacia-Commiphora* bushland.

Dipeolu (1976b) collected *nivosus* in low numbers by light trap from around cattle and small ruminant pens in all areas of Nigeria except mangrove swamps; adults were slightly more abundant in the Sudan zone.

Braverman & Hulley (1979) predicted the host preference of *nivosus* to be birds based on the high number of antennal and palpal sensilla. In South Africa, Nevill & Anderson (1972) showed that *nivosus* fed on larger mammals and on birds based on precipitin tests of blood-engorged females.

**Distribution.** Ethiopia, Gambia, Kenya, Mozambique, Nigeria, Senegal, South Africa, Uganda, Zimbabwe.

**Material Examined.** ETHIOPIA: Gama-Gofa Province, Chew Bahir, at marsh and hot spring, 575 ft elev., V. H. Lee, light trap, 12-13-III-75, 2 ♀♀. GAMBIA: West Kiang District, Keneba, D. H. Murphy, light trap, 20-XI-59, 1 ♀. KENYA: Amboseli, J. P. Rieb, blacklight trap, 5-I-78, 1 ♀. Nairobi, Kabete, Dr. Davies' garden, C. L. Bailey, light

#### SCALE EQUIVALENCES KEY

1.0 mm

.5 mm

.1 mm

.05 mm

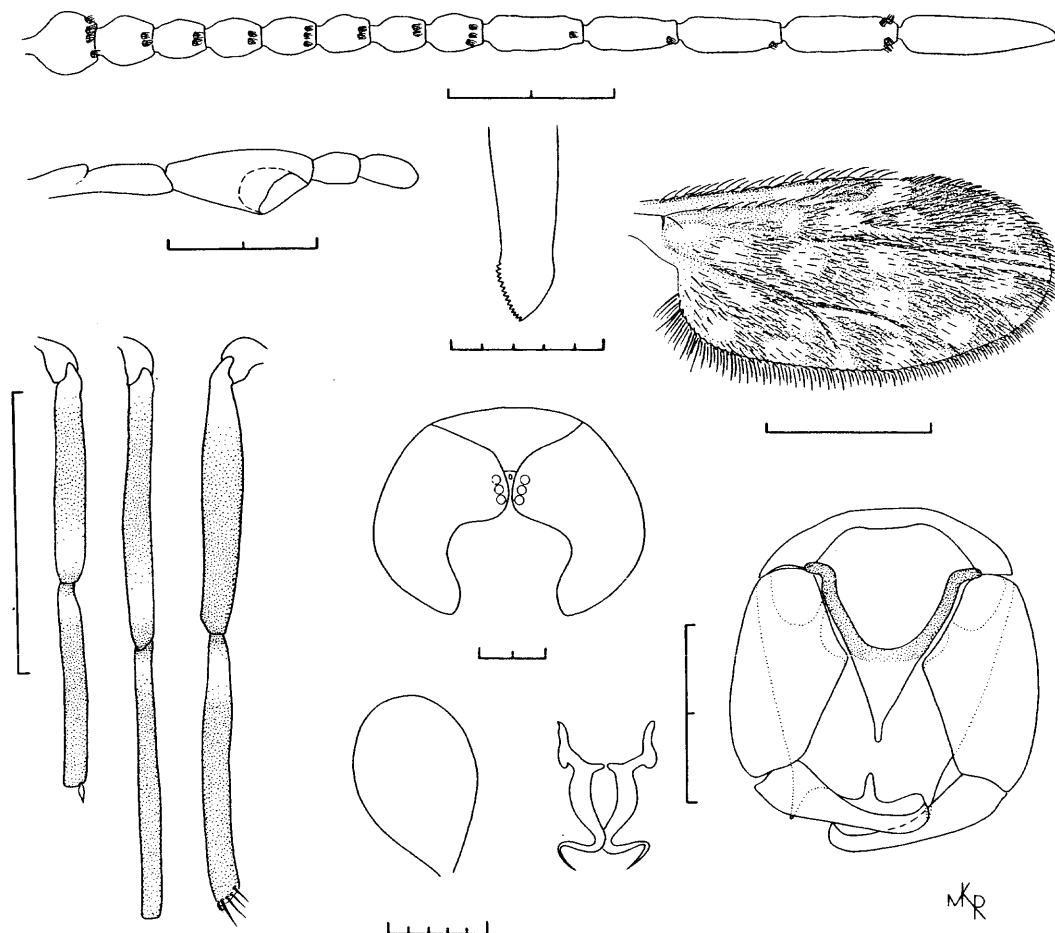


Fig. 2. *Culicoides (Beltranmyia) pycnostictus*. Adult female, male genitalia. (See key for scale.)

trap and CO<sub>2</sub>, 19-20-V-82, 2 ♀♀. Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey and Kairo, light trap and CO<sub>2</sub>, 25-26-V-82, 2 ♀♀; same data, 28-V-82, 1 ♀. NIGERIA: Kankiya, B. McMillan, light trap, II-57, 6 ♀♀, 3 ♂♂. UGANDA: Lake Mulehe, T. Petr, light trap, 16-XII-70, 1 ♀. ZIMBABWE: Salisbury, E. T. Reid, light trap, IV-56, 1 ♀; same data, 30-V-56, 1 ♀, 1 ♂; Magondi Reserve, C. Green, 3-II-70, 1 ♀.

*Culicoides (Beltranmyia) pycnostictus*  
Ingram & Macfie  
(Fig. 2)

*Culicoides pycnostictus* Ingram & Macfie 1925: 284 (male, female, pupa). Types: 2 ♀♀, 1 ♂, pupal exuviae of 1 ♀ and 1 ♂, Nyasaland, Fort Johnston, W. A. Lamborn, 4-XII-23 (BMNH).

*Culicoides alexis* De Meillon 1936: 147 (male, female, pupa). Holotype: ♂, Ofcolaco, Transvaal, 1933. Paratype: ♀, same data as holotype (IMRJ).

*Culicoides meeserellus* De Meillon 1936: 151 (male, pupa). Holotype: ♂, Tzaneen, Transvaal, reared

from pupa collected from rot hole in pawpaw tree, C. Meeser, 11-XII-32 (IMRJ).

**Diagnosis.** A moderately large, dark brown species. Female eyes very narrowly separated; sensilla coeloconica on antennal segments 3-14; 3rd segment of maxillary palpus greatly expanded, with a deep sensory pit. Wing with prominent pattern of small to moderately large pale spots; pale spot over r-m crossvein small and rounded; cell R5 with a pale spot near base, a rounded pale spot on anterior wing margin just distad of 2nd radial cell, a pale spot just below and distal to the anterior spot, and a pale spot in distal portion of cell near apex. Female abdomen with a large, ovoid spermatheca. **Male Genitalia.** Distal median process of aedeagus broad, tapering to a slender, rounded apex; parameres separate, main stem stout, distal portion sinuate, tapering to a slender, pointed apex.

**Female.** Wing length 1.22 mm (1.05-1.40 mm,  $n = 15$ ). **Head.** Dark brown. Eyes very narrowly separated by a distance less than the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 18-12-13-13-13-13-14-14-22-23-23-24-38; A.R.

1.18 (1.09–1.27,  $n = 15$ ); sensilla coeloconica (with number per segment) on segments 3(7–11), 4(3–5), 5(2–4), 6(2–5), 7(2–4), 8(2–4), 9(2–4), 10(2–4), 11(1–2), 12(1–2), 13(1–2), 14(5–9). Third segment of maxillary palpus greatly expanded, with a large, rounded, deep sensory pit; P/R. 2.12 (2.00–2.28,  $n = 15$ ). Proboscis moderately long, P/H 0.84 (0.78–0.89,  $n = 15$ ); mandible with 14 teeth (13–15,  $n = 15$ ).

**Thorax.** Dark brown. Legs dark brown; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band; hindtibial comb with 4 spines, that nearest the spur longest. Halter infuscated pale brown.

**Wing.** Macrotrichia long and abundant over entire wing. Wing with prominent pattern of rounded pale spots between the veins; a small, rounded pale spot over r-m crossvein coalescing anteriorly with a small pale spot on costal margin; cell R5 with a moderately large pale spot near base, a pale spot on anterior margin just distad of the 2nd radial cell, a pale spot just below and distal to the anterior spot, and a pale spot in distal portion near apex; cell M1 with a pale spot at base and a spot in distal portion; cell M2 with 2 pale spots in basal portion, a pale spot just below median fork, and 2 pale spots in distal portion of cell; cell M4 with a pale spot at apex; anal cell with 2 elongate pale spots in basal portion and 2 rounded pale spots in distal portion, often coalescing; veins M1, M2, M3+4, and Cu1 pale-margined to apices. Costal ratio 0.55 (0.52–0.57,  $n = 15$ ).

**Abdomen.** Dark brown. Spermatheca dark brown, ovoid, without sclerotized neck, 0.083 by 0.063 mm (0.071–0.104 by 0.058–0.076 mm,  $n = 15$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, slender apicolateral processes; caudal margin with a deep mesal cleft. Ninth sternum with a broad, deep, caudomedian emargination; ventral membrane not spiculate. Basistyle with long, slender dorsal root, ventral root absent; dististyle nearly straight, distally tapering, with a curved, pointed apex. Aedeagus with a broad, deep basal arch; lateral arms moderately slender, bases bent laterally; distal median process broad, tapering to a slender, rounded apex. Parameres separate; basal knob large, lateral margin with slender, anteriorly directed process; main stem moderately to greatly swollen, distal portion sinuate, tapering to a very slender, pointed apex.

**Discussion.** Khamala & Kettle (1971) placed *pyncostictus* in their *distinctipennis* group (= *Meijerehelea*) on the basis of its similarity in wing pattern (especially to *leucostictus*), abundant macrotrichia, antennal sensory pattern, third segment of maxillary palpus, one spermatheca, and similar male genitalia. However, *pyncostictus* is more closely related to the subgenus *Beltranmyia* on the basis of the ovoid spermatheca.

**Bionomics.** Ingram & Macfie (1921) described the pupa of *pyncostictus* from adults reared at Fort Johnston, Nyasaland (Malawi). De Meillon (1936)

described and illustrated the pupa (as *alexis* and *meeserellus*). The pupa of *meeserellus* was obtained from a rot hole of a pawpaw tree in the northern Transvaal. He also reared several adults from pupae obtained in muddy pools at several localities in Zululand (De Meillon 1937). Nevill (1969) described and illustrated the fourth instar and pupa from South African material.

In Kenya, Khamala (1975) reared *pyncostictus* from a variety of habitats at Lake Nakuru National Park, including mud and wet soil at river edges, mud mixed with bird excreta on the lake edge, water-logged mud with decaying vegetation in a *Cyperus* marsh, wet soil from edges of rainwater pools in *Hyperrhenia-Chloris* grasslands, water-logged mud from a *Typha* swamp, wet soil from *Cynodon-Thameda* grassland fields, and mud at the edges of artificial drainage trenches. It was most abundant in the *Cyperus* marsh and the *Typha* swamp. Lubega & Khamala (1976) reared *pyncostictus* in Kenya from decaying, moist litter mixed with soil from forest floors and from decaying banana stems.

At Eruwa, Nigeria, Dipeolu & Ogunrinade (1976) found *pyncostictus* emerging from boggy ground of a rocky hill site and from underneath partially water-logged canoes, crab holes, other natural or artificial holes, and rotten vegetation along the bank of the Opeki River.

In Zimbabwe, Braverman (1978) found the main breeding site of *pyncostictus* to be mud at the edges of bodies of water (especially dams); it also was reared from around puddles rich in organic matter, from along drainage canals with mud intermediate to very low in organic matter, and from along streams and drainage canals with mud poor in organic matter. Adults were reared throughout the year; the highest numbers occurred in January, July, and August and the lowest in February and March.

Khamala (1971) collected large numbers of adults by light trap in East Africa from various savanna zones in Kenya and Uganda. Walker (1976) collected *pyncostictus* in Kenya from high-altitude forests and grasslands, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

In South Africa, Nevill & Anderson (1972) showed that *pyncostictus* clearly favored feeding on birds based on precipitin tests of blood-fed females, although one female was positive for cattle and two for horses. Adults were caught mostly in a control (garden) trap; otherwise it was most common near poultry. In Nigeria, Dipeolu (1976a) collected adults in small numbers at the University of Ibadan research farm from sites near wild animals.

**Distribution.** Ethiopia, Gambia, Kenya, Malawi, Mali, Nigeria, Senegal, South Africa, Sudan, Tanzania, Uganda, Zimbabwe.

**Material Examined.** ETHIOPIA: Shoa Province, Sodere resort, near Awash River and hot springs, 1,400 ft elev., V. H. Lee, light trap, 5-IV-

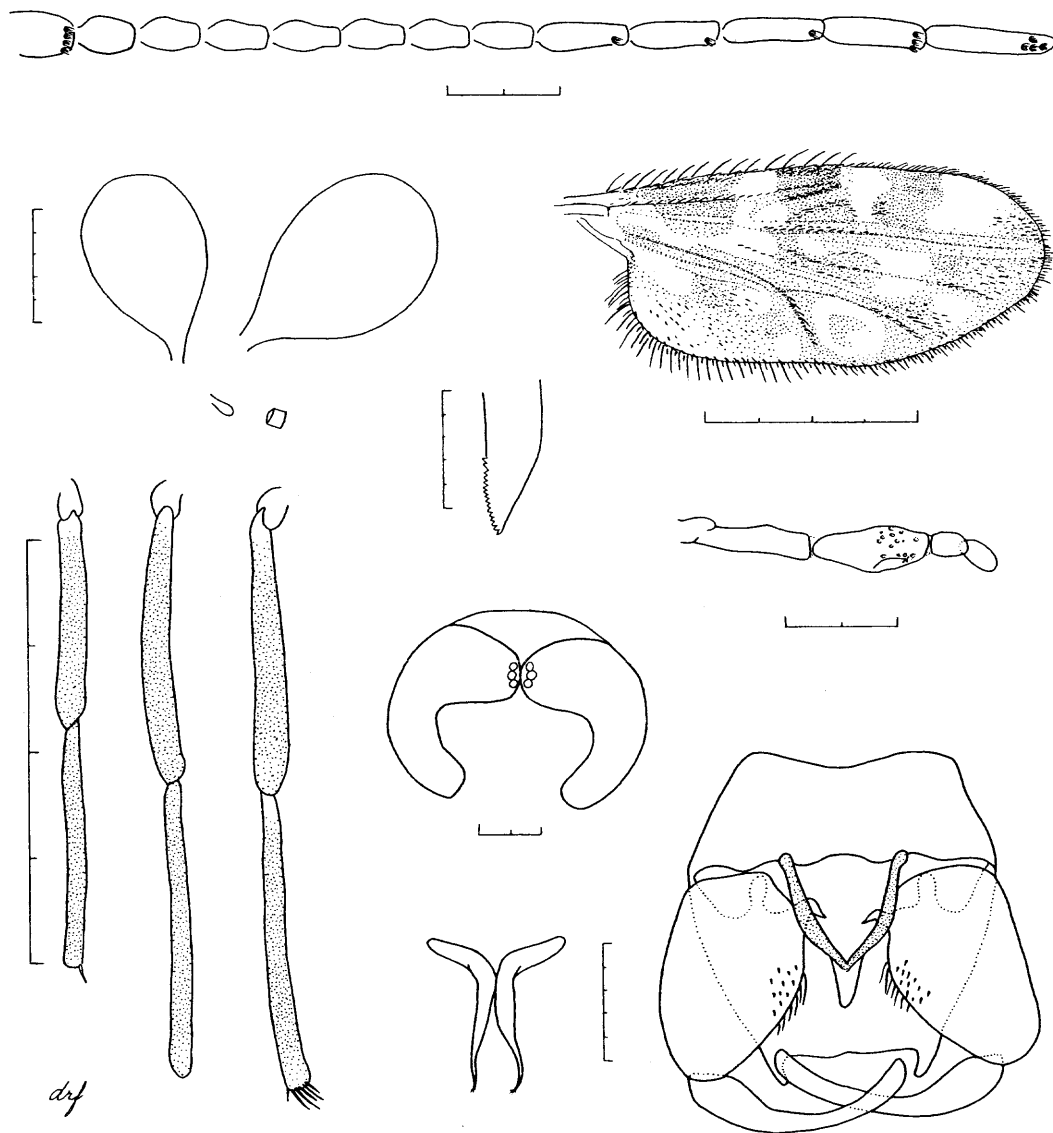


Fig. 3. *Culicoides (Culicoides) brucei*. Adult female, male genitalia. (See key for scale.)

75, 1 ♀; same data, 12-13-IV-75, 1 ♀. GAMBIA: West Kiang District, Keneba, in house, D. H. Murphy, 12-V-56, 1 ♂; same data, 11-VIII-57, 1 ♂. KENYA: Nairobi Province, Nairobi, Karen, 800 m W Karen Rd. and 500 m S Bongani Rd., N fork Mbagathi River, Noad Farm, 1,850 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 19-XI-81, 1 ♀; Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 19-22-V-82, 5 ♀♀, 1 ♂; same data, 25-V-82, 1 ♀; same data, 27-28-V-82, 2 ♀♀; same data, 3-VI-82, 1 ♀; Kabete, Dr. Davies' garden, C. L. Bailey, light trap and CO<sub>2</sub>, 19-V-82, 1 ♀; same data except C. L. Bailey and Kairo, 25-V-82, 1 ♀. NIGERIA: Kankiya, B. McMillan, light trap, 1-II-56, 1 ♀; same data, I-57, 1 ♂; same data, II-57, 6 ♀♀, 8 ♂♂. SOUTH AFRICA: Natal, Merrivale District, Pietermaritzburg, B.

Stuckenberg, light trap, V-80, 1 ♀, 1 ♂. ZIMBABWE: Kariba, 1,675 ft elev., D. R. Birkenmeyer, blacklight trap, 26-X-67, 1 ♂; Salisbury, E. T. Reid, light trap, 30-V-56, 2 ♀♀, 2 ♂♂; same data, VIII-56, 3 ♀♀, 3 ♂♂; same data, 2-II-57, 1 ♀; same data, VI-57, 1 ♂; same data, VII-57, 1 ♀, 1 ♂; same data, VIII-57, 4 ♀♀, 1 ♂.

#### Subgenus *Culicoides* Latreille s. str.

*Culicoides* Latreille 1809: 251. Type species: *Culicoides pulicaris* (Linnaeus) as *Culicoides punctata* Latreille (original designation).

**Diagnosis.** Female eyes usually contiguous. Female antenna with sensilla coeloconica usually on segments 3, 11-15. Third segment of maxillary pal-

pus with scattered sensilla on ventral side, or grouped in a round to irregular, shallow pit. Hindtibial comb with 5–7 spines. Wing with prominent dark and pale markings and may have a separate dark spot in middle of cell M4; 2nd radial cell ending in a pale spot. Female abdomen with 2 ovoid spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with apicolateral processes short or absent to well-developed and slender, caudal margin variable from straight to rounded, often exceeding length of apicolateral processes; basistyle usually with short ventral root and moderately long dorsal root, inner margin or mesal surface of basistyle usually with a prominent area of setae or spines; aedeagus variable, usually with a moderately broad, deep basal arch, distal median process stout or tapering to a rounded or blunt apex; parameres separate, usually sharply bent laterad near base, stem usually moderately long and slender, tapering distally to a slender, pointed apex with minute setae.

**Kenya Species.** *C. brucei* Austen, *C. magnus* Colaco, *C. sylvicola* Khamala & Kettle.

***Culicoides (Culicoides) brucei* Austen**  
(Fig. 3)

*Culicoides brucei* Austen 1909: 282 (female). Holotype: ♀, vic. Mianga River, near Tororo, Uganda Protectorate, biting man, D. Bruce, VII-03 (BMNH).

*Culicoides pseudopulicaris* Goetghebuer 1935b: 173 (female). Holotype: ♂ no. 42 MK, Rutshuru, Belgian Congo, Dr. De Wulf, I-34 (MRAC).

*Culicoides hirtius* De Meillon & Lavoipierre 1944: 58 (male). Holotype: ♂, Onderstepoort, Transvaal, R. du Toit, at light, no date (IMRJ).

*Culicoides pulicaris* of authors, not Linnaeus (misident.).

*Culicoides punctatus* of authors, not Meigen (misident.).

**Diagnosis.** A large, dark brown species. Female antennal segments brown; sensilla coeloconica on segments 3, 11–15; 3rd segment of maxillary palpus with sensilla scattered in many small, shallow pits. Wing with extensive pale markings; cell R5 with a very large, broad pale spot in distal ½, extending almost to apex; apices of veins M1 and M2 pale. **Male Genitalia.** Ninth tergum with moderately short apicolateral processes; inner margin of basistyle with a prominent patch of spines; basal arch of aedeagus very deep, V-shaped; distal median process of aedeagus tapering to a rounded apex.

**Female.** Wing length 1.46 mm (1.11–1.93 mm,  $n = 15$ ). **Head.** Dark brown; antennal segments brown. Eyes contiguous for a distance equal to the diameter of about ½ to 2 ocular facets; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 20–14–14–16–16–16–17–21–20–22–23–35; A.R. 0.97 (0.88–1.04,  $n = 15$ );

sensilla coeloconica (with number per segment) on segments 3(4–5), 11(1), 12(1), 13(1–2), 14(2–3), 15(4). Third segment of maxillary palpus slender, only slightly expanded distally, distal portion with many small, shallow sensory pits, often also with 1 or 2 larger pits; P.R. 3.05 (2.50–3.39,  $n = 15$ ). Proboscis moderately long, P/H 0.84 (0.80–0.88,  $n = 15$ ); mandible with 15 teeth (13–18,  $n = 15$ ).

**Thorax.** Dark brown. Legs dark brown; femora pale basally; tibiae each with a narrow basal pale band, hindtibia weakly paler at apex; hindtibial comb with 5 spines (occasionally 6), the 2nd from the spur longest. Halter pale.

**Wing.** Macrotrichia moderately sparse over most of wing. Wing with extensive pale markings; base of wing with a large, irregular pale area extending into base of cell M2 and base of anal cell; a very large pale spot over r-m crossvein extending anteriorly to costal margin and posteriorly into an irregular pale area below median fork; cell R5 with a large, irregular pale spot on anterior margin covering distal ½ of 2nd radial cell; area below radial cells somewhat paler; distal portion of cell R5 with a very large, broad pale spot in distal ½, extending almost to apex; cell M1 with a small pale spot at base, an irregular pale area at middle, and a small pale area in distal portion of cell, the pale areas usually narrowly coalescing; cell M2 with 2 pale spots in distal portion, the proximal pale spot coalescing with the spot in middle of cell M1; cell M4 with a very large pale spot filling almost entire cell and a small, dark spot in the middle, forming a pale ring; anal cell with 2 pale spots in distal portion, spot near apex often ill-defined; vein M1 weakly pale-margined for most of its length to base; apices of veins M1 and M2 weakly pale. Costal ratio 0.57 (0.55–0.58,  $n = 15$ ).

**Abdomen.** Dark brown. Spermathecae unequal, ovoid, with short, tapering, sclerotized necks; rudimentary 3rd short and narrow; sclerotized ring short; functional spermathecae 0.065 by 0.049 mm (0.048–0.094 by 0.037–0.064 mm,  $n = 15$ ) and 0.060 by 0.044 mm (0.044–0.082 by 0.035–0.053 mm,  $n = 15$ ).

**Male Genitalia.** Ninth tergum with strongly tapering sides and short, slender apicolateral processes, moderately curved inward. Ninth sternum with a shallow caudomedian emargination; ventral membrane not spiculate. Basistyle with a long, stout, apically rounded dorsal root and shorter, slender, apically pointed ventral root, apex curving posterolaterally; inner margin of basistyle with a patch of moderately long spines at midlength; dististyle broad basally, abruptly tapering just before middle, distal portion curved, moderately slender, with bluntly pointed apex. Aedeagus with a very deep, V-shaped basal arch, lateral arms moderately slender; distal median process stout basally, tapering to a rounded apex. Paramere with basal ½ bent anterolaterally; distal portion of stem nearly straight, tapering to a slender, pointed apex with minute setae.

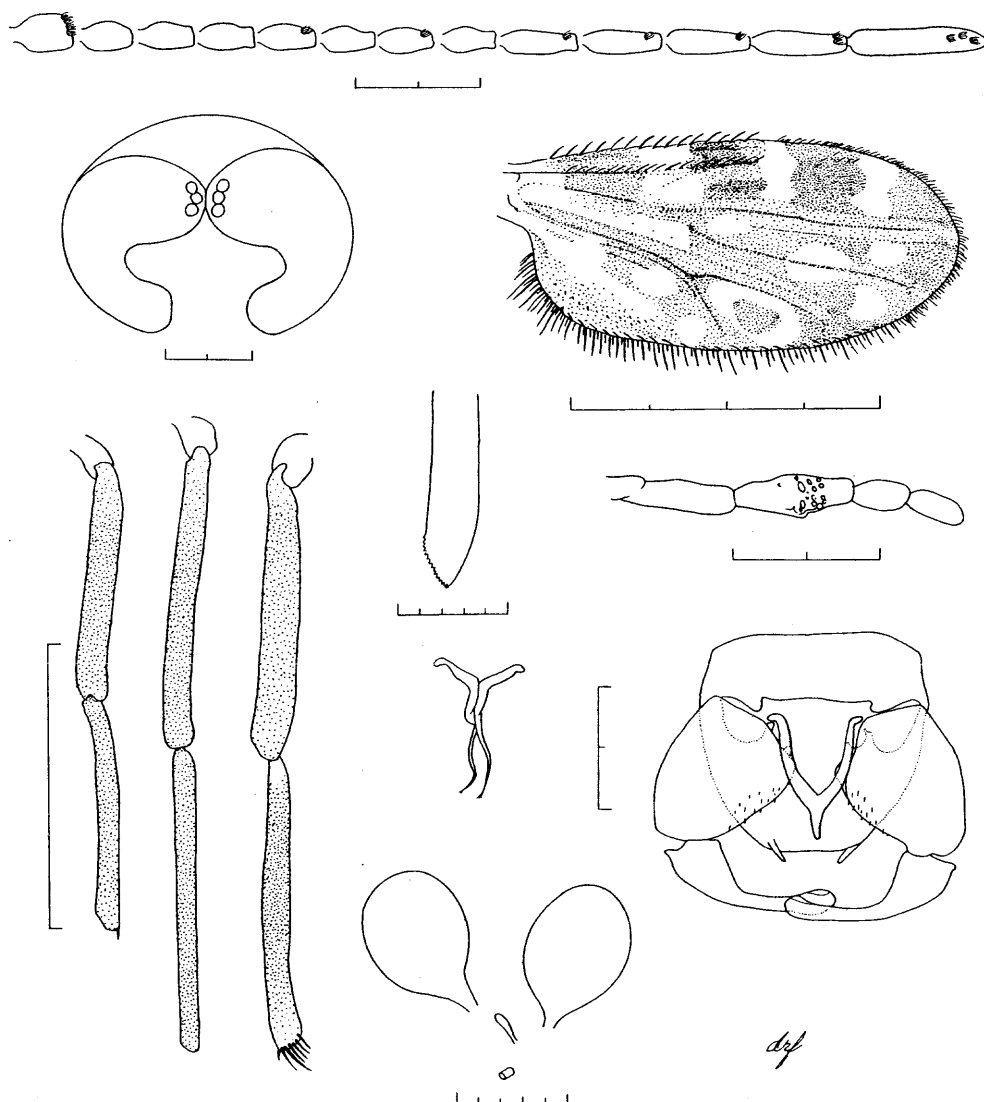


Fig. 4. *Culicoides (Culicoides) magnus*. Adult female, male genitalia. (See key for scale.)

**Discussion.** Females of *brucei* can be best separated from those of *magnus* by the large, broad pale spot near the apex of cell R5; by the sensilla coeloconica on antennal segments 3, 11–15 rather than on 3, 7, 9, 11–15; and by the brownish (rather than yellowish) proximal antennal segments. *C. sylvicola* is a smaller species with a darker wing and more restricted pale markings. The apices of veins M1 and M2 are dark in *sylvicola*, and the third segment of the maxillary palpus has one large, shallow sensory pit and a second smaller one rather than scattered sensilla.

**Bionomics.** The immature stages of *brucei* are undescribed.

Lubega & Khamala (1976) reared adults in Kenya from water-logged mud in freshwater marshes overgrown with *Cyperus* and *Typha*; from mud mixed with animal feces; and from free water from

puddles, slow-flowing streams, artificial drainage trenches, and water-filled concrete troughs for watering livestock.

*Culicoides brucei* has been taken by light trap throughout the year in the Afrotropical Region. Khamala (1971) collected adults from forested zones in Kenya and from various savanna zones in Kenya, Tanzania, and Uganda. Walker (1976) collected *brucei* in Kenya from high-altitude forests and grasslands, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

The low number of antennal and palpal sensilla indicate that *brucei* feeds primarily on large mammals (Braverman & Hulley 1979). The type series was taken by D. Bruce (Austen 1909) while females were biting humans in the vicinity of the Mianga River, Uganda Protectorate. Based on precipitin

tests of blood-engorged females, Walker & Boreham (1976) determined that the hosts of *brucei* include birds and bovines with a preference for bovines. In Nigeria, Dipeolu (1976b) collected *brucei* in low numbers near cattle and small ruminant pens in the forest and plateau regions.

**Distribution.** Ethiopia, Ivory Coast, Kenya, Nigeria, South Africa, Tanzania, Uganda, Zaire, Zimbabwe.

**Material Examined.** ETHIOPIA: Addis Ababa, J. Lane, light trap, X-55, 17 ♀♀, 13 ♂♂; Gama-Gofa Province, Lake Chamo, 1,200 ft elev., V. H. Lee, light trap, 1-2-V-75, 1 ♀; Wallo Province, Kutaber, 23 km NW Dessie, 2,650 m elev., R. W. Ashford, 7-IX-71, 4 ♀♀; same data, 21-IX-71, 1 ♀; same data, X-71, 39 ♀♀, 2 ♂♂; same data, 5-X-71, 1 ♀; same data, 15-XI-71, 1 ♀, 1 ♂. NIGERIA: Kaduna. Hayi River, V. H. Lee, light trap, 27-28-X-70, 1 ♀; Kankiya, B. McMillan, at light, II-57, 1 ♀. SOUTH AFRICA: Natal, Merrivale District, Pietermaritzburg, B. Stuckenberg, at light, V-80, 3 ♀♀, 1 ♂. ZIMBABWE: Salisbury, E. T. Reid, light trap, IV-56, 4 ♀♀; same data, 30-V-56, 12 ♀♀; same data, VIII-56, 4 ♀♀; same data, IX-56, 7 ♀♀; same data, X-56, 8 ♀♀; same data, 13-XII-56, 1 ♀; same data, IV-57, 5 ♀♀, 1 ♂; same data, VI-57, 2 ♀♀; same data, VII-57, 1 ♀; same data, VIII-57, 18 ♀♀, 4 ♂♂.

*Culicoides (Culicoides) magnus* Colaco  
(Fig. 4)

*Culicoides hirtius* var. *magnus* Colaco 1946: 237 (male, female). Holotype: ♀, Onderstepoort, Transvaal, A. T. F. Colaco, light trap, XII-44-II-45 (IMRJ).

*Culicoides magnus* Colaco; Fiedler 1951: 9.

**Diagnosis.** A large, dark brown species. Female antenna with sensilla coeloconica usually on segments 3, 7, 9, 11-15; proximal 8 antennal segments yellowish; 3rd segment of maxillary palpus with many small, shallow sensory pits on distal ½. Wing pattern similar to *brucei*, except pale markings not as extensive; pale spot in distal portion of cell R5 subapical, transverse. **Male Genitalia.** Ninth tergum with short, slender apicolateral processes; inner margin of basistyle with a prominent patch of spines; aedeagus with a very deep, V-shaped basal arch; distal median process of aedeagus slender, apex rounded.

**Female.** Wing length 1.64 mm (1.43-1.79 mm,  $n = 6$ ). **Head.** Dark brown; proximal 8 antennal segments pale yellowish. Eyes contiguous for a distance equal to the diameter of about 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 28-22-23-25-24-22-23-22-30-32-35-37-50; A.R. 0.94 (0.91-0.97,  $n = 6$ ); sensilla coeloconica usually on segments 3, 7, 9, 11-15, often absent from segments 7 or 9, occasionally present on segments 5 or 10; number of sensilla per segment: 3(3-4), 5(0-1), 7(0-1), 9(0-1), 10(0-1), 11(1), 12(1), 13(1-2), 14(2), 15(3-4).

Third segment of maxillary palpus slightly broadened at midlength, with numerous, small, shallow sensory pits on distal ½; P.R. 2.70 (2.53-2.90,  $n = 6$ ). Proboscis moderately long, P/H 0.84 (0.82-0.88,  $n = 6$ ); mandible with 14 teeth (13-16,  $n = 6$ ).

**Thorax.** Dark brown. Legs dark brown; femora pale basally; fore- and midtibiae narrowly pale basally, hindtibia pale at base and broadly paler at apex; hindtibial comb with 6 spines, 2nd from the spur longest. Halter pale.

**Wing.** Macrotrichia moderately dense over most of wing. Wing pattern similar to that of *C. brucei*; wing darker, the pale markings somewhat more restricted; pale spot in distal portion of cell R5 subapical, transverse, often with a mesal constriction or entirely divided. Costal ratio 0.57 (0.56-0.59,  $n = 6$ ).

**Abdomen.** Dark brown. Spermathecae unequal, ovoid, with short, tapering, sclerotized necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.074 by 0.049 mm (0.066-0.078 by 0.043-0.051 mm,  $n = 6$ ) and 0.067 by 0.047 mm (0.060-0.076 by 0.044-0.049 mm,  $n = 6$ ).

**Male Genitalia.** Ninth tergum with tapering sides, nearly rounded; caudal margin nearly straight, with short, slender apicolateral processes. Ninth sternum with a broad, shallow caudomedian emargination; ventral membrane not spiculate. Basistyle short and very broad, inner margin with a prominent patch of short spines; dorsal root short and stout, ventral root very short; dististyle broad basally, tapering to middle, distal portion abruptly curved, expanding to a more or less rounded apex. Aedeagus with a deep, V-shaped basal arch, lateral arms slender; distal median process moderately short, slender, with rounded apex. Paramere with base anterolaterally directed; stem slender, tapering to a pointed apex with minute setae.

**Bionomics.** Nevill (1969) described and illustrated the fourth instar from South African material.

In Kenya, Khamala (1975) reared *magnus* from mud and wet soil taken from river edges at Lake Nakuru National Park. Walker & Davies (1971) found larvae at the margins of ditches and pools in habitats characterized by fine mud with a high organic detritus content. Braverman (1978) reared two females from mud samples taken at the edges of water bodies in the Salisbury area of Zimbabwe.

Khamala (1971) collected adults in Kenya from savanna zones. Walker (1976) collected *magnus* from high-altitude forests and grasslands, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

Dipeolu (1976b) collected *magnus* in low numbers from cattle and small ruminant pens in the forest and Guinea zones of Nigeria. In Gambia, Claestrier & Wirth (1961) reported adults from a palm scrub and rice swamp and from a forest at Lamin. One female also was taken while biting

cattle at Talindingkunda. Walker & Davies (1971) noted that *magnus* was a dominant species within the bluetongue enzootic area of Kenya, with adults concentrated around sheep. Precipitin tests from blood-engorged females were positive predominantly for sheep and cattle. In South Africa, precipitin tests were positive for horses and cattle (Nevill & Anderson 1972).

**Distribution.** Gambia, Kenya, Nigeria, South Africa, Zimbabwe.

**Material Examined.** KENYA: Nairobi Province, Nairobi, Karen, Rees Barn, Mbagathi River, 1,800 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 29-X-81, 3 ♀♀; same locality except Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 19-V-82, 3 ♀♀; Nainvasha, J. P. Rieb, blacklight trap, 17-I-78, 1 ♀. SOUTH AFRICA: Natal, Merrivale District, B. Stuckenberg, light trap, V-80, 1 ♀; Cape, Tygerhoek, E. M. Nevill, 10-I-71, 1 ♂. ZIMBABWE: Salisbury, E. T. Reid, light trap, 30-V-56, 2 ♀♀; same data, VIII-56, 1 ♀; same data, VII-57, 3 ♀♀; same data, VIII-57, 2 ♀♀.

*Culicoides (Culicoides) sylvicola*  
Khamala & Kettle  
(Fig. 5)

*Culicoides sylvicola* Khamala & Kettle 1971: 36 (female). Holotype: ♀, Kaimosi, Kenya, C. Khamala, light trap, 15-IX-66 (BMNH).

**Diagnosis.** A medium-sized, dark brown species. Female antenna with sensilla coeloconica on segments 3, 11–15; 3rd segment of maxillary palpus with 1 large, shallow sensory pit and a 2nd smaller one; proboscis short. Wing dark, pale markings reduced; apices of veins dark. Male unknown.

**Female.** Wing length 1.16–1.26 mm ( $n = 2$ ). **Head.** Dark brown. Eyes contiguous for a distance equal to the diameter of about 2 ocular facets; without interfacetal setae. Antenna with flagellar lengths in proportion of 21–18–17–17–18–18–19–25–26–27–29–42; A.R. 1.02–1.11 ( $n = 2$ ); sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(3), 15(4). Third segment of maxillary palpus moderately expanded distally, with 1 large, shallow sensory pit and a 2nd smaller one; P.R. 2.45–2.58 ( $n = 2$ ). Proboscis short, P/H 0.68; mandible with 15–16 teeth ( $n = 2$ ).

**Thorax.** Dark brown. Legs dark brown; femora pale basally and apically; fore- and midtibiae narrowly pale basally, hindtibia broadly pale basally, apex paler; hindtibial comb with 6 spines, 2nd from the spur longest. Halter infuscated pale brown.

**Wing.** Macrotrichia moderately abundant over most of wing. Wing pattern similar to that of *C. magnus*; wing darker with the pale spots more restricted; pale spot over r-m crossvein with a constriction over radial vein; cell R5 with a large, rounded, moderately distinct, subapical pale spot;

apices of veins dark. Costal ratio 0.58–0.59 ( $n = 2$ ).

**Abdomen.** Dark brown. Spermathecae slightly unequal, ovoid, with short, tapering, sclerotized necks; rudimentary 3rd short and narrow; sclerotized ring short; functional spermathecae 0.059–0.064 by 0.043–0.045 mm ( $n = 2$ ) and 0.055–0.060 by 0.041–0.044 mm ( $n = 2$ ).

**Male.** Unknown.

**Discussion.** Khamala & Kettle (1971) placed *sylvicola* in the *milnei* group on the basis of the third palpal segment and the distribution of antennal sensilla. They noted it was readily distinguished by the pale ring in cell M4 (resembling *magnus* and *brucei*) but did not place it in the *magnus* group (=subgenus *Culicoides*) because of the less well-defined pale spots and the dark apices of the veins.

**Bionomics.** The immature stages and larval habitat of *sylvicola* are undescribed.

Khamala (1971) collected one female by light trap from a forest zone in Kenya. Braverman & Hulley (1979) predicted the host preference of *sylvicola* to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Ethiopia, Kenya.

**Material Examined.** ETHIOPIA: Kaffa Province, Aposhasha Village, 3-h walk S of Genji, 1,150 ft elev., V. H. Lee, light trap, 18–19-VI-74, 2 ♀♀.

**Subgenus *Meijerehelea* Wirth & Hubert**

*Culicoides*, subgenus *Meijerehelea* Wirth & Hubert 1961: 23. Type species: *Ceratopogon guttifer* de Meijere (original designation).

**Diagnosis.** Female eyes usually narrowly separated; without interfacetal setae. Female antenna with sensilla coeloconica on segments 3–15 or 3–14. Third segment of maxillary palpus with a single, distal sensory pit. Hindtibial comb with 4 spines. Wing with distinct pattern of pale spots, including a pale spot just distad of 2nd radial cell, a pale spot at apex of cell R5, and sometimes 1 or more additional pale spots below 2nd radial cell; cell M1 with 2 pale spots; cell M2 with a pale spot near base of cubital stem, a pale spot proximal to cubital fork, and 2 pale spots in distal portion of cell; anal cell usually with a zigzag pale streak near base, and 2 pale spots near apex; 2nd radial cell usually dark to apex; macrotrichia abundant. Female abdomen with 1 functional spermatheca, ovate to saccate or sagittate, duct usually elongated. **Male Genitalia.** Ninth tergum with well-developed apicolateral processes; basistyle with ventral root short or absent, dorsal root long; aedeagus with moderately slender to stout arms, distal median process stout; parameres separate, basal knob large and directed laterad, stem tapering to a simple, pointed apex.

**Kenya Species.** *C. distinctipennis* Austen, *C. ischnoensis* Glick, n. sp., *C. leucostictus* Kieffer.



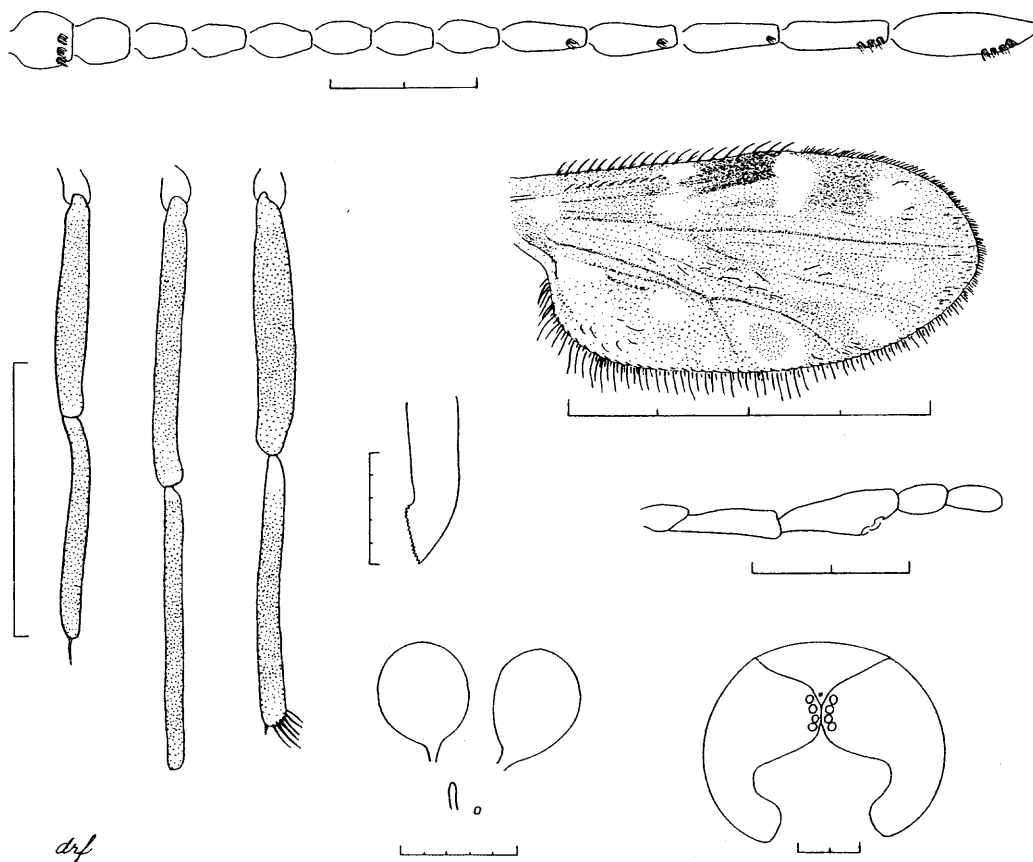


Fig. 5. *Culicoides* (*Culicoides*) *sylvicola*. Adult female. (See key for scale.)

***Culicoides* (*Meijerehelea*) *distinctipennis*  
Austen  
(Fig. 6)**

*Culicoides distinctipennis* Austen 1912: 101 (female). Holotype: ♀, Lagos, Yaba, Nigeria, in veranda of bungalow, W. M. Graham, V-09. Paratypes: 1 ♀, same data as holotype except caught near lamp at 2100 hours, 18-V-09; 3 ♀♀, Chagwe, Kibanga, Uganda Protectorate, A. D. Fraser, VIII-10 (BMNH).

**Diagnosis.** A medium-sized, dark brown species. Females eyes very narrowly separated, almost contiguous; sensilla coeloconica on antennal segments 3–15. Wing with 3 pale spots in cell R5, including a rounded pale spot near base of cell, a transverse pale spot on anterior margin just distad of 2nd radial cell, and a rounded pale spot near apex. Female abdomen with sagittate-shaped spermatheca. **Male Genitalia.** Distal median process of aedeagus tapering to a slender process with caplike apex; main stem of paramere stout, greatly expanded distally, abruptly tapering near apex to a slender, laterally recurved, pointed tip.

**Female.** Wing length 1.12 mm (0.89–1.58 mm,  $n = 8$ ). **Head.** Dark brown. Eyes very narrowly

separated by a distance less than the diameter of  $\frac{1}{2}$  an ocular facet, almost contiguous; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 17–11–11–12–12–12–13–13–23–24–28–29–40; A.R. 1.48 (1.37–1.66,  $n = 6$ ); sensilla coeloconica (with number per segment) on segments 3(3–6), 4(1–2), 5(1–2), 6(1–2), 7(1–2), 8(1–2), 9(1–2), 10(1), 11(1), 12(1), 13(1), 14(3–7), 15(1). Third segment of maxillary palpus moderately expanded, with a large, rounded, moderately deep sensory pit; P.R. 2.42 (2.08–2.67,  $n = 7$ ). Proboscis long, P/H 0.85 (0.73–1.00,  $n = 8$ ); mandible with 13 teeth (11–15,  $n = 8$ ).

**Thorax.** Dark brown. Legs dark brown; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band; hindtibial comb with 4 spines, that nearest the spur longest. Halter infuscated brown.

**Wing.** Macrotrichia abundant over most of wing except at base. Wing with distinct pattern of small, rounded pale spots; a narrow pale spot over r-m crossvein coalescing with a spot just above it on anterior wing margin; cell R5 with a pale spot near base just below 1st radial cell, a moderately large transverse pale spot on anterior wing margin just distad of 2nd radial cell, and a pale spot near apex;

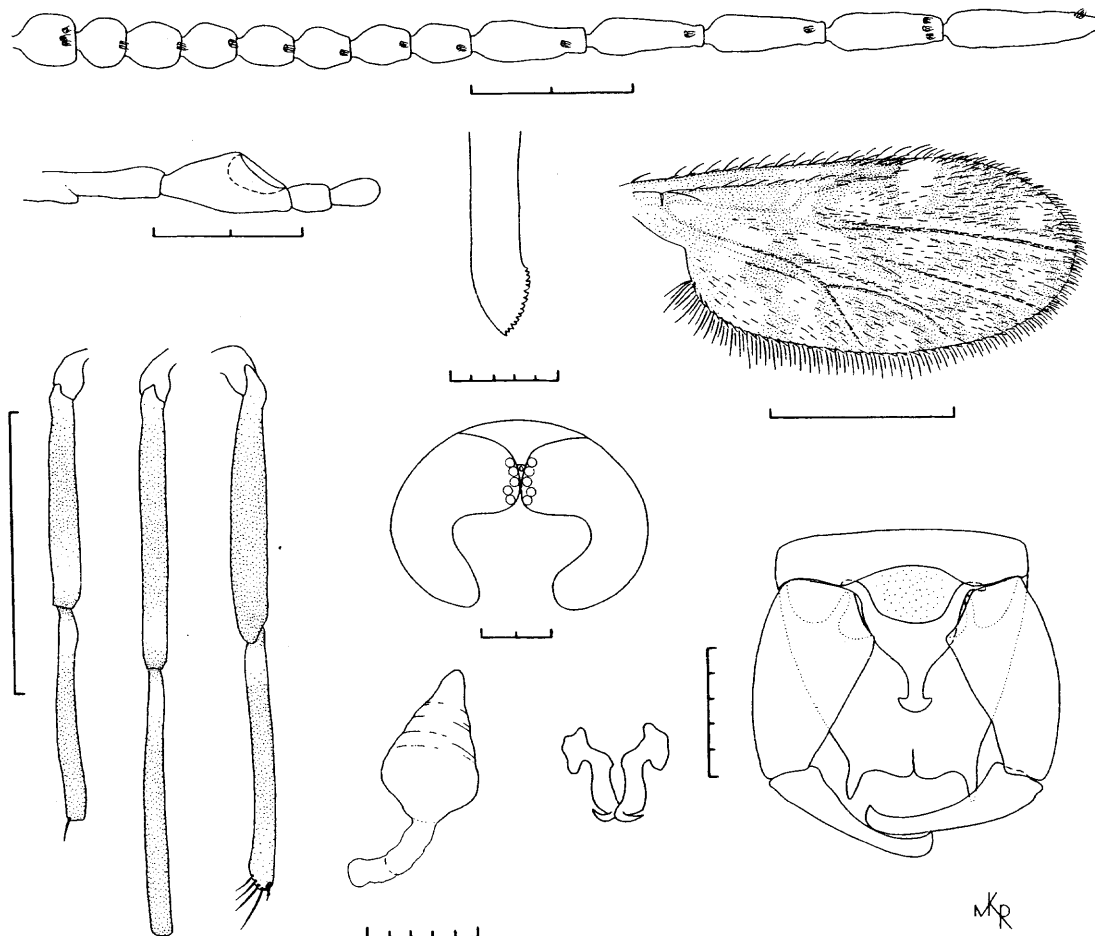


Fig. 6. *Culicoides (Meijerehelea) distinctipennis*. Adult female, male genitalia. (See key for scale.)

cell M1 with a pale spot near base and another near apex; cell M2 with a pale spot at base, a pale spot proximal to cubital stem at its midlength, a pale spot just below median fork, and 2 pale spots in distal portion of cell; cell M4 with a pale spot at apex; anal cell with an irregular, zigzag pale marking in basal portion, often coalescing with the pale spot just above cubital stem, a pale spot just below cubital fork, and a spot just below at wing margin, the 2 distal spots sometimes coalescing; veins M1, M2, M3+4, and Cu1 pale-margined. Costal ratio 0.59 (0.55–0.60,  $n = 8$ ).

**Abdomen.** Brown. Spermatheca sagittate-shaped, moderately sclerotized, 0.078 mm long (0.064–0.092 mm,  $n = 5$ ), 0.046 mm at greatest width (0.038–0.058 mm,  $n = 8$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, moderately slender apicolateral processes; caudal margin with a deep mesal cleft. Ninth sternum with a broad, shallow caudomedian emargination; ventral membrane spiculate. Basistyle with long, slender dorsal root with rounded apex, ventral root very short; dististyle slightly curved, tapering

distally, apex curved with pointed tip. Aedeagus with a moderately deep, broad, basal arch; lateral arms moderately slender, bases curved laterally; distal median process tapering to a slender process with caplike apex. Paramere with large, angulate basal knob directed anterolaterally; main stem stout, greatly expanded distally, abruptly tapering near apex to a slender, laterally recurved, pointed tip.

**Discussion.** Many authors have noted the absence of *distinctipennis* males with a typical wing, those collected all having a wing pattern similar to that of *leucostictus*; however, most of these males are true *leucostictus* because *distinctipennis* does not have the extra pale spot present in cell R5.

The presence of *distinctipennis* in Egypt is certainly possible, but previous records should be viewed as *leucostictus* until *distinctipennis* is confirmed. Unfortunately, it has been carried in the literature as occurring in Egypt ever since Nagaty & Morsy (1960a,b) incorrectly listed the nominate variety rather than variety *egypti* (= *leucostictus*); in the same year, they (Nagaty & Morsy 1960c) noted they would continue its use to designate the

species in Egypt until it was proven that any other forms have significance. Macfie (1943) noted that *pharao* Kieffer was probably the same as *egypti*; however, the synonymy of the two is uncertain because the original description of *pharao* is poor and types are not available.

**Bionomics.** The pupa was originally described by Ingram & Macfie (1921) from a single male exuvium obtained in Ghana. Nevill (1969) described and illustrated the fourth instar and pupa from South African material.

Ingram & Macfie (1921) reared numerous adults from moist soil and mud taken from the margins of pools and puddles at Accra, Ghana, and from the water weed *Pistia stratiotes* taken with a little surrounding water from pools or river backwaters of the Densu River at Oblogo (Macfie & Ingram 1923). In Cameroon, Hopkins (1952) reared adults from larvae collected in boggy ground, usually thinly covered with grass and decumbent plants such as *Comelina* sp. In Kenya, Lubega & Khamala (1976) reared *distinctipennis* from mud taken at the edges of various bodies of water, with or without vegetative cover and usually frequented by livestock.

Dipeolu & Ogunrinade (1976) collected adults in Nigeria using emergence traps at sites near the Opeki River and from a rocky hill site at Eruwa. Larval populations at both places were high during the dry season with a peak in December, decreased to a minimum during June and July, then adults emerged during the rains from May to October with a peak in June. At the University of Ibadan research farm (Dipeolu & Ogunrinade 1977), adults were most numerous from emergence traps placed on the margins of a dairy cattle drinking trough, but they also were collected in low numbers from traps placed along an open drain leading from a slaughterhouse. Emergence occurred throughout the year with peaks in June and August.

Braverman (1978) found *distinctipennis* to be third in abundance in mud samples taken at the edge of water bodies in the Salisbury area. It was the dominant species along drainage canals in mud intermediate in organic matter; it also was found around puddles rich in organic matter or in mud along streams and drainage canals that were very poor in organic matter. Breeding continued throughout the year with the greatest numbers reared in July and August.

Light trap records indicate *distinctipennis* is probably present in the Afrotropical Region throughout most of the year; Clastrier (1960) collected adults in the Congo during September, December, April, and May, and Clastrier & Wirth (1961) give records for Nigeria from October to February and for Gambia during May, July, and August. Kremer (1972b) recorded adults from Angola during all months except April and October. Dipeolu & Ogunrinade (1976) found *distinctipennis* the most abundant species near the Opeki River in Nigeria, making up about 30% of the total *Cu-*

*licoides* collections. Populations were almost constant throughout the year except during peaks of rainfall in June and July when there was a slight drop in numbers. It was second in abundance at a rocky hill site, where it did not occur until the middle of the rainy season (May), then reached a peak in July. In East Africa, adults have been collected from forest (Uganda) and savanna zones (Kenya, Uganda) (Khamala 1971). Walker (1976) collected *distinctipennis* in Kenya from high-altitude forests and grasslands, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland. In West Africa, Dipeolu (1976b) collected adults in all areas of Nigeria (especially the forest, derived savanna, and southern Guinea zones) with a daily peak abundance from 0100 to 0500 hours and peak numbers of engorged females from 0500 to 0700 hours.

Host preference based on precipitin tests of blood-engorged females indicates that *distinctipennis* is primarily a bird feeder (Nevill & Anderson 1972, Braverman et al. 1977), although females also have been collected while biting humans in Zaire (De Meillon 1937) and Senegal (Cornet 1969). Braverman et al. (1977) noted its preference for birds on the basis of the high number of antennal and palpal sensilla. In South Africa, Nevill & Anderson (1972) found that *distinctipennis* fed only on birds (probably poultry), although a large percentage was collected in a trap near horses and mules. It represented less than 1.1% of the catches near cattle, sheep, and mules (none engorged) but 47.4% of catches near poultry (9.5% engorged). At the University of Ibadan research farm, Nigeria, Dipeolu (1976a) collected females from sites near wild animals where it constituted almost 5% of the total *Culicoides*. He also found it to feed on poultry by precipitin testing of engorged females trapped around poultry houses (Dipeolu 1977).

**Distribution.** Angola, Cameroon, Congo, Egypt(?), Ethiopia, Gambia, Ghana, Guinea, Kenya, Madagascar, Mali, Nigeria, São Tomé, Senegal, Sierra Leone, South Africa, Sudan, Tanzania, Uganda, Zaire, Zimbabwe.

**Material Examined.** ETHIOPIA: Kaffa Province, Chebara, Kulu Konta, Hot Springs, V. H. Lee, light trap and CO<sub>2</sub>, 20-21-IX-74, 1 ♀; Wallo Province, Asaita, near Awash River, 500 m elev., V. H. Lee, light trap, 25-27-IX-74, 1 ♀. GAMBIA: West Kiang District, Keneba, D. H. Murphy, light trap, 6-VII-56, 1 ♂; same data, 16-VII-56, 1 ♀; same data except Madwan Swamp, 4-V-57, 1 ♂; same data, 12-VIII-57, 1 ♂; same data except sticky trap in hollow tree, tall grass savanna, 11-V-59, 1 ♂; North Kombo District, Lamin, forest, D. H. Murphy, light trap, 12-II-60, 1 ♂. KENYA: Western Province, Kakamega Forest Reserve, Isechno, 750 m N Kakamega Forest Station, edge of primary forest and along grazing grassland, 1,530 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 5-XI-81, 2 ♀♀; Nairobi, Karen, Bowdens property, Karen Rd.,

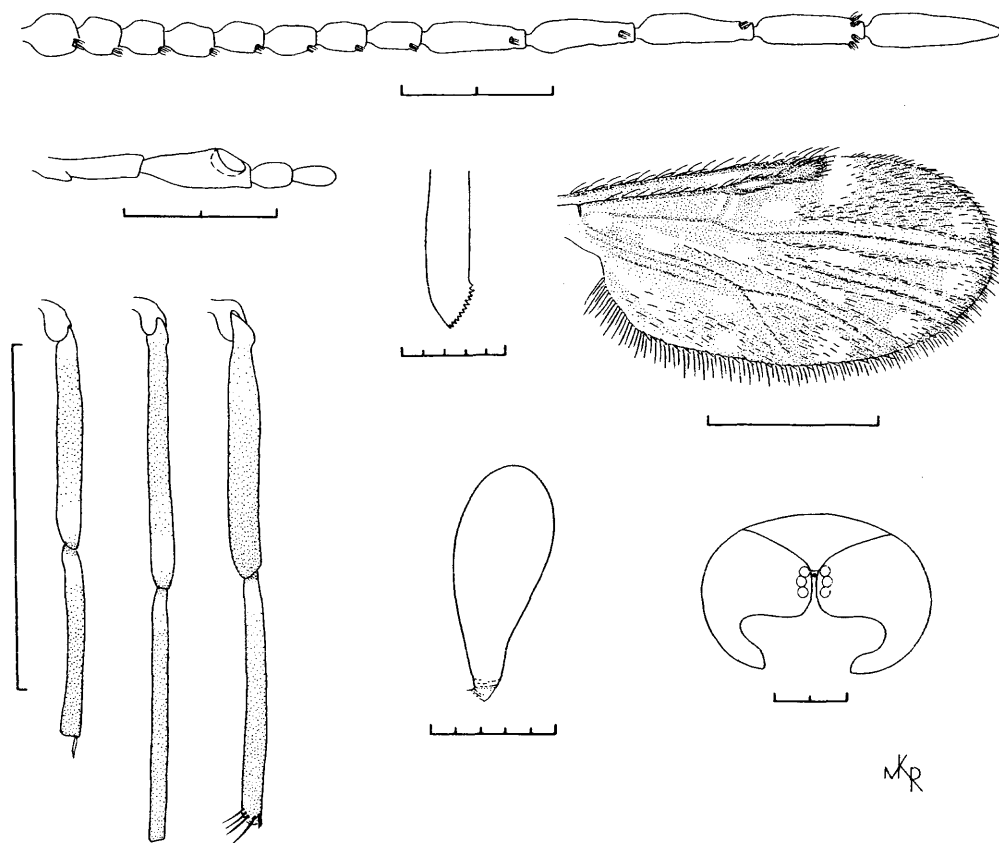


Fig. 7. *Culicoides (Meijerehelea) ischnoensis*, n. sp. Adult female. (See key for scale.)

1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 3-VI-82, 1 ♀. NIGERIA: Kaduna, B. McMillan, at light, 25-X-55, 1 ♀. ZAIRE: Coquilhatville, A. B. Stam, light trap, III-IV-62, 2 ♂♂; same data, V-62, 1 ♀, 1 ♂; same data, VIII-62, 2 ♀♀.

***Culicoides (Meijerehelea) ischnoensis* Glick,  
new species  
(Fig. 7)**

**Diagnosis.** A moderately large, brownish species. Female eyes narrowly separated; sensilla coeloconica on antennal segments 3-14. Wing pattern similar to that of *C. distinctipennis*, cell R5 with 3 pale spots, proximal pale spot lying below junction of 1st and 2nd radial cells. Female abdomen with spermatheca elongate-ovoid.

**Female.** Wing length 1.21 mm (1.11-1.34 mm,  $n = 25$ ). **Head.** Brown. Eyes narrowly separated by a distance equal to the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 25-19-18-18-18-19-19-20-39-42-43-41-53; A.R. 1.41 (1.32-1.51,  $n = 20$ ); sensilla coeloconica (with number per segment) on segments 3(1-3), 4(1), 5(1), 6(1), 7(1), 8(1), 9(1), 10(1), 11(1), 12(1), 13(1), 14(4-6). Third segment of maxillary palpus moderately swollen, with a large, rounded, moderately shallow

sensory pit; P.R. 2.46 (2.25-2.58,  $n = 20$ ). Proboscis moderately long, P/H 0.84 (0.80-0.89,  $n = 23$ ); mandible with 13 teeth (12-14,  $n = 25$ ).

**Thorax.** Brown; mesonotum with 2 narrow, sub-lateral, longitudinal pale bands forming a broad, median, longitudinal brown band, widening posteriorly; scutellum yellowish brown with darker margins. Legs brown; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band; hindtibial comb with 4 spines, that nearest the spur longest. Halter infuscated pale brownish, distal portion of knob usually entirely pale.

**Wing.** Macrotrichia confined mostly to distal  $\frac{1}{2}$  of wing and distal portion of anal cell. Wing with a large transverse pale spot over r-m crossvein, extending anteriorly to costal margin, broadened in costal cell; cell R5 with 3 pale spots, including a small, ovoid spot in proximal portion below junction of 1st and 2nd radial cells, a large transverse spot on anterior margin just distad of 2nd radial cell, and a rounded pale spot at apex; cell M1 with an elongate-ovoid pale spot in proximal  $\frac{1}{2}$ , and a rounded pale spot near apex; cell M2 with a pale spot at base, a spot just above cubital vein at its midlength, a spot just below median fork, an elongate spot in distal  $\frac{1}{2}$  directly below proximal spot of cell M1, and a pale spot at apex; a very narrow

pale streak running through middle of cell M2 from basal spot to 4th spot in distal portion, coalescing with 2nd and 3rd pale spots; cell M4 with a moderately large, rounded pale spot at apex; anal cell with an elongate pale streak in proximal ½, broadening distally, and with 2 rounded pale spots in distal portion, 1 just below apex of 1st anal vein, the other directly below near wing margin; proximal ½ of wing margin in anal cell usually narrowly pale-margined; wing pale spots occasionally somewhat enlarged, especially the 2 distal spots in anal cell, but not coalescing; proximal pale spot in cell R5 often reduced, caudal portion of transverse pale spot distad of 2nd radial cell occasionally narrowed. Costal ratio 0.60 (0.58–0.61,  $n = 25$ ).

**Abdomen.** Brown. Spermatheca elongate-ovoid, tapering at base, with broad duct, well-sclerotized and pigmented brownish, 0.083 mm long (0.072–0.093 mm,  $n = 25$ ), 0.038 mm at greatest width (0.031–0.042 mm,  $n = 23$ ).

**Etymology.** The specific name is derived from the type locality.

**Discussion.** *Culicoides isechoensis* can be distinguished from *distinctipennis*, which it most closely resembles, by its antennal sensory pattern of 3–14 rather than 3–15, and by its elongate-ovoid spermatheca. It also is similar to the Oriental species *Culicoides arakawai* (Arakawa) but can be differentiated by differences in the position of the pale spots in cell R5, the lack of a mesonotal pattern, and the slightly different shape of the spermatheca.

**Bionomics.** The immature stages and larval habitat of *isechoensis* are unknown.

The type series was collected by light trap with CO<sub>2</sub> from the Kakamega Forest in early November. No males were collected; they may appear very similar to the other species of the subgenus in Kenya.

The feeding habits of *isechoensis* are unknown, although it is suspected to have a preference for birds based on the high number of antennal sensilla.

**Distribution.** Western Kenya; known only from the type locality.

**Type Material.** HOLOTYPE: ♀, Western Province, Kenya, Kakamega Forest Reserve, Isechno, 500 m N Kakamega Forest Station, 100 m into forest, 1,530 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 5-XI-81 (USNM Type No. 100465). PARATYPES: 48 ♀♀, same data as holotype; 1 ♀, same data as holotype except 750 m N Kakamega Forest Station, on edge of primary forest and large grazing grassland, 5-XI-81; 3 ♀♀, same data except 9-XI-81. Holotype and 42 paratypes, USNM; 4 paratypes, BMNH; 2 paratypes, ORSB; 1 paratype, MHNP; 1 paratype, IPS; 2 paratypes, NMK.

*Culicoides (Meijerehelea) leucostictus* Kieffer  
(Fig. 8)

*Culicoides leucostictus* Kieffer 1911: 340 (female).

No types designated. Type locality: Mahé, Sey-

chelles, marshes on coastal plain, at Anse aux Pins and Anse Royale, 19–21-I-09.

*Culicoides praetermissus* Carter, Ingram & Macfie 1920: 240 (male). Types: Accra, Gold Coast, on lab windows, A. Ingram and J. W. S. Macfie (BMNH).

*Culicoides distinctipennis* var. *praetermissus* Carter et al.; Fiedler 1951: 5.

*Culicoides distinctipennis* var. *egypti* Macfie 1924: 66 (female). Holotype: ♀, Nile at Assuit, Egypt, J. W. S. Macfie, 14-XII-23 (BMNH).

*Culicoides egypti* Macfie 1943: 154 (male, female).

**Diagnosis.** A medium-sized, dark brown species. Female eyes narrowly separated; sensilla coeloconica on antennal segments 3–15. Wing pattern similar to that of *C. distinctipennis* except with a pale spot present just below and distal to the transverse pale spot on anterior wing margin. Female abdomen with spermatheca sagittate-shaped. **Male Genitalia.** Similar to that of *C. distinctipennis*, except aedeagus stouter distally; main stem of paramere very stout basally, tapering distally.

**Female.** Wing length 1.05 mm (0.92–1.35 mm,  $n = 24$ ). **Head.** Dark brown. Eyes narrowly separated by a distance less than the diameter of 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 18–12–12–12–12–12–13–13–23–24–25–28–37; A.R. 1.32 (1.13–1.52,  $n = 24$ ); sensilla coeloconica (with number per segment) on segments 3(3–7), 4(1–2), 5(1–3), 6(1–2), 7(1–3), 8(1–3), 9(1–3), 10(1–2), 11(1–2), 12(1), 13(1–2), 14(3–7), 15(1–2). Third segment of maxillary palpus moderately expanded, with a large, rounded, moderately deep sensory pit; P.R. 2.31 (2.00–2.50,  $n = 24$ ). Proboscis long, P/H 0.86 (0.77–0.93,  $n = 24$ ); mandible with 14 teeth (12–15,  $n = 24$ ).

**Thorax.** Dark brown. Legs dark brown; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band; hindtibial comb with 4 spines, that nearest the spur longest. Halter infuscated brown.

**Wing.** Macrotrichia abundant over most of wing except at base. Wing with distinct pattern of small, rounded pale spots between the veins, almost identical to *C. distinctipennis* except for the presence of a pale spot just below and distal to the transverse pale spot on anterior wing margin, sometimes these two spots coalescing; the transverse pale spot on anterior margin often with a slight to moderate constriction at middle; the 2 distal pale spots in anal cell occasionally coalescing. Costal ratio 0.57 (0.54–0.59,  $n = 24$ ).

**Abdomen.** Brown. Spermatheca moderately sclerotized, sagittate-shaped, 0.070 mm long (0.062–0.081 mm,  $n = 24$ ), 0.044 mm at greatest width (0.039–0.056 mm,  $n = 24$ ).

**Male Genitalia.** Similar to that of *C. distinctipennis*, with the following differences: aedeagus stouter distally; main stem of paramere very stout basally, tapering distally.

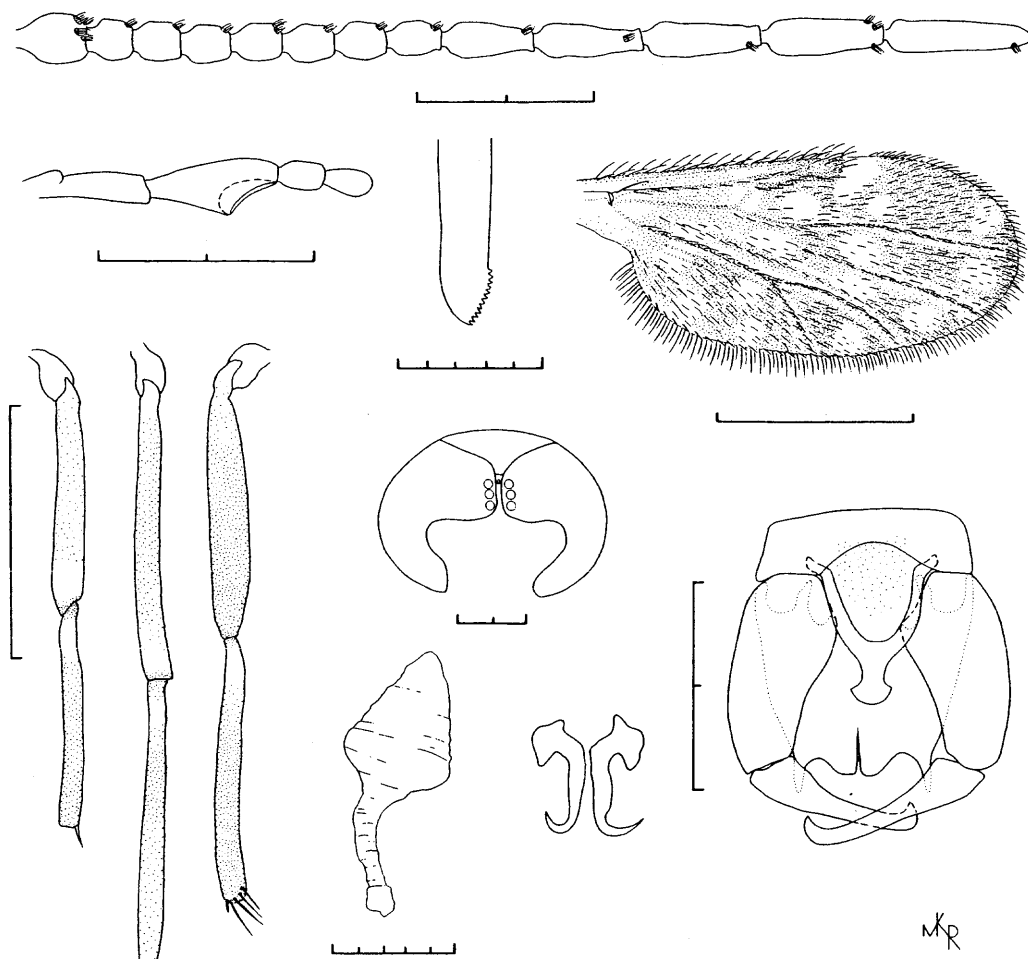


Fig. 8. *Culicoides (Meijerehelea) leucostictus*. Adult female, male genitalia. (See key for scale.)

**Discussion.** Macfie (1924, 1943) reported adults collected in Egypt which were apparently the same as variety *egypti*, although the wing pattern was similar to that of *praetermissus*. He also noted (Macfie 1943) that *pharao* was probably the same as *egypti*, but he could not be sure because types were not available and Kieffer's (1924) description was inadequate. De Meillon (1943) synonymized *distinctipennis* variety *egypti* with *praetermissus*. Fiedler (1951), noting this synonymy, placed *praetermissus* as a variation of *distinctipennis* for those specimens with an extra pale spot in cell R5 (*leucostictus*). Nagaty & Morsy (1960c) also noted that variety *egypti* should more properly be *distinctipennis* variety *praetermissus*; however they opted for the nominate name for their Egyptian material. Their illustrations (Nagaty & Morsy 1961a) of the wing, spermatheca, and male genitalia are clearly those of *leucostictus*.

Callot et al. (1965b) listed *distinctipennis* for Cameroon, although they noted that the male wing pattern corresponded to that of *distinctipennis*

*praetermissus* (= *leucostictus*) (they believed this difference to be one of sexual dimorphism).

Khamala & Kettle (1971) placed this species (as *praetermissus*) in the *distinctipennis* group rather than in the subgenus *Meijerehelea*.

Kremer et al. (1975) synonymized a female type of *Forcipomyia multiguttata* Goetghebuer (1935b, 156) (no. 47 MK [labeled by Kremer], Vitshumbi, Belgian Congo, Dr. De Wulf, X-33; [MRAC]) as *distinctipennis*, noting that this particular specimen corresponded to variety *praetermissus*. Their illustration of the wing of that female is apparently that of *leucostictus*. From the description they give of the wing, it is difficult to be certain whether their synonymy of two female paratypes of *wansoni* Goetghebuer (1935a, 477) (B and D MK [labeled by Kremer], Banana, Belgian Congo, Dr. Wanson, II-35; [MRAC]) with *distinctipennis* actually refers to *leucostictus* because they did not illustrate the wings of any *wansoni* type material (types of *multiguttata* and *wansoni* were not available for study).

Wirth & Messersmith (1977) synonymized *praetermissus* and *distinctipennis* var. *egypti* with *leucostictus* after examining material of *leucostictus* from the Seychelles.

**Bionomics.** The immature stages of *Culicoides leucostictus* are undescribed.

Callot et al. (1967a) reared *leucostictus* in Senegal from a substrate sample of mud taken from a stream-fed pond serving as an animal watering site. Lubega & Khamala (1976) reared adults (as *praetermissus*) in Kenya from mud taken at the edges of ponds and puddles and from decaying banana stems. In Nigeria, Dipeolu & Ogunrinade (1976) found adults (as *praetermissus*) emerging at Eruwa from rot holes on the rocks and from boggy ground of a rocky hill site. At the Opeki River, adults emerged from mud taken from underneath partially water-logged canoes, from crab holes and other natural or artificial holes, and from rotten vegetation along the river bank. At the University of Ibadan research farm (Dipeolu & Ogunrinade 1977), adults were collected in low numbers from emergence traps placed along the margins of a dairy cattle drinking trough and from the margins of an open drain leading from a slaughterhouse.

In Israel, Braverman et al. (1974) obtained *leucostictus* adults from artificial breeding sites made from various small containers filled with a mixture of soil and cow manure, and from artificial puddles created from different combinations of soil, manure, and other additives.

Khamala (1971) reported *leucostictus* (as *praetermissus*) from the forest and savanna zones of East Africa (Kenya and Uganda). Walker & Davies (1971) noted that it had a relatively low distribution within the bluetongue enzootic area of Kenya. In Nigeria, Dipeolu (1976a) collected *leucostictus* in low numbers from sites near wild animals at the University of Ibadan research farm (28.8% blood-fed).

In Israel, *leucostictus* (as *praetermissus*) was a dominant species in collections from turkey houses (Braverman et al. 1974, 1976; Braverman & Rubina 1976); high numbers of engorged females were shown to have taken avian blood by precipitin tests, whereas in light-trapping near mammals (sheep, cattle, and horses), engorged females were not collected (Braverman & Rubina 1976, Braverman et al. 1977).

**Distribution.** Cameroon, Cyprus, Egypt, Ethiopia, Ghana, Guinea, Israel, Kenya, Mozambique, Nigeria, Senegal, Seychelles, South Africa, Sudan, Uganda, Zimbabwe.

**Material Examined.** CAMEROON: Waza, J. A. Gruwell, blacklight trap, 19-III-72, 1 ♀, 2 ♂♂. EGYPT: Behiera Governorate, 29-VI-73, 1 ♂; Giza Governorate, Bulaq El Dakrur, T. Ali, X-58, 1 ♀, 1 ♂; Menia Governorate, 24-V-73, 4 ♀♀; Kafr Tarkhan, El Saff Center, T. A. Morsy, 7-X-59, 1 ♂. ETHIOPIA: Illubabor Province, Gambela, 1,750 ft elev., B. McMillan, 25-26-VII-74, 2 ♀♀, 1 ♂; Wallo Province, Dupte, Tendaho cotton plantation, V. H. Lee,

light trap, 24-25-IX-74, 2 ♀♀; Gila River, Mission Station, M. L. Schmitt, light trap, II-70, 1 ♀. KENYA: Coast Province, Mombasa, Diani, Diani Forest, 1,000 m W of Coverdale Farm, C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 23-XI-81, 2 ♀♀; same data, 28-XI-81, 2 ♂♂; same data, 29-XI-81, 2 ♀♀, 1 ♂; Nairobi Province, Nairobi, Karen, 800 m W Karen Rd., 500 m S Bongani Rd., N fork Mbagathi River, Noad Farm, lower stream forest, 1,850 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 17-IX-81, 1 ♀; same data, 4-XII-81, 1 ♂; same locality except Bowdens property, Karen Rd., C. L. Bailey, light trap and CO<sub>2</sub>, 21-V-82, 1 ♀; same data, 25-26-V-82, 2 ♀♀; Nairobi, Kabete, Dr. Davies' garden, C. L. Bailey and Kairo, light trap and CO<sub>2</sub>, 25-V-82, 1 ♀; Western Province, Kakamega Forest Reserve, Isechno, 750 m N Kakamega Forest Station, on edge of primary forest and large grazing grassland, 1,530 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 5-IX-81, 1 ♀, 1 ♂. NIGERIA: Kankiya, B. McMillan, light trap, XII-55, 1 ♂; same data, I-57, 1 ♀; same data, II-57, 2 ♂♂. SEYCHELLES: Mahe, Beau Vallon, W. T. Tams and I. W. Nye, 30-III-65, 1 ♀; same data, 29-IV-65, 1 ♂; Reef Hotel Golf Course, D. H. Messersmith, blacklight trap, 22-V-72, 9 ♀♀, 1 ♂. SOUTH AFRICA: Natal, Merrivale District, Pietermaritzburg, B. Stuckenberg, light trap, V-80, 1 ♀, 1 ♂. SUDAN: Upper Nile Province, Paloich, L. Quate, light trap, 12-X-63, 9 ♀♀, 1 ♂. ZIMBABWE: Kariba, 1,675 ft elev., D. R. Birkenmeyer, blacklight trap, 4-X-67, 1 ♂; same data, 14-X-67, 2 ♂♂; same data, 25-26-X-67, 4 ♀♀, 10 ♂♂; same data, 25-XI-67, 4 ♀♀, 3 ♂♂; same data, 6-X-68, 2 ♀♀; same data, 2-XI-68, 1 ♂; Salisbury, E. T. Reid, light trap, 30-V-56, 1 ♀, 1 ♂; same data, VIII-56, 2 ♀♀; same data, IX-56, 1 ♀, 1 ♂; same data, X-56, 4 ♀♀, 4 ♂♂; same data, 22-II-57, 1 ♀, 1 ♂; same data, IV-57, 2 ♀♀, 1 ♂; same data, VII-57, 1 ♀; same data, VIII-57, 4 ♀♀, 6 ♂♂; same data, 23-IX-57, 1 ♂; Nkai Region, Nkapi Dam, R. J. Phelps, truck trap, 23-III-81, 1 ♂; Ruya Camp, R. J. Phelps, II-70, 1 ♀; Burma Valley, Masapa Farm, V. Clarke, 12-II-71, 2 ♀♀.

#### Subgenus *Monoculicoides* Khalaf

*Culicoides*, subgenus *Monoculicoides* Khalaf 1954:  
39. Type species: *Ceratopogon nubeculosus* Meigen (original designation).

**Diagnosis.** Female eyes broadly separated, without interfacetal setae. Female antenna with sensilla coeloconica on segments 3, 7-10 or 3, 8-10. Third segment of maxillary palpus with a single, distal sensory pit. Hindtibia with 5-7 spines. Wing pattern of irregular pale spots and streaks; 2nd radial cell dark to apex; macrotrichia moderately abundant. Female abdomen with 1 large, functional spermatheca, shape variable from elongate-ovoid to C-shaped, opening of duct wide. *Male Genitalia.* Ninth tergum with prominent apicolateral processes; basistyle with ventral root short, dor-

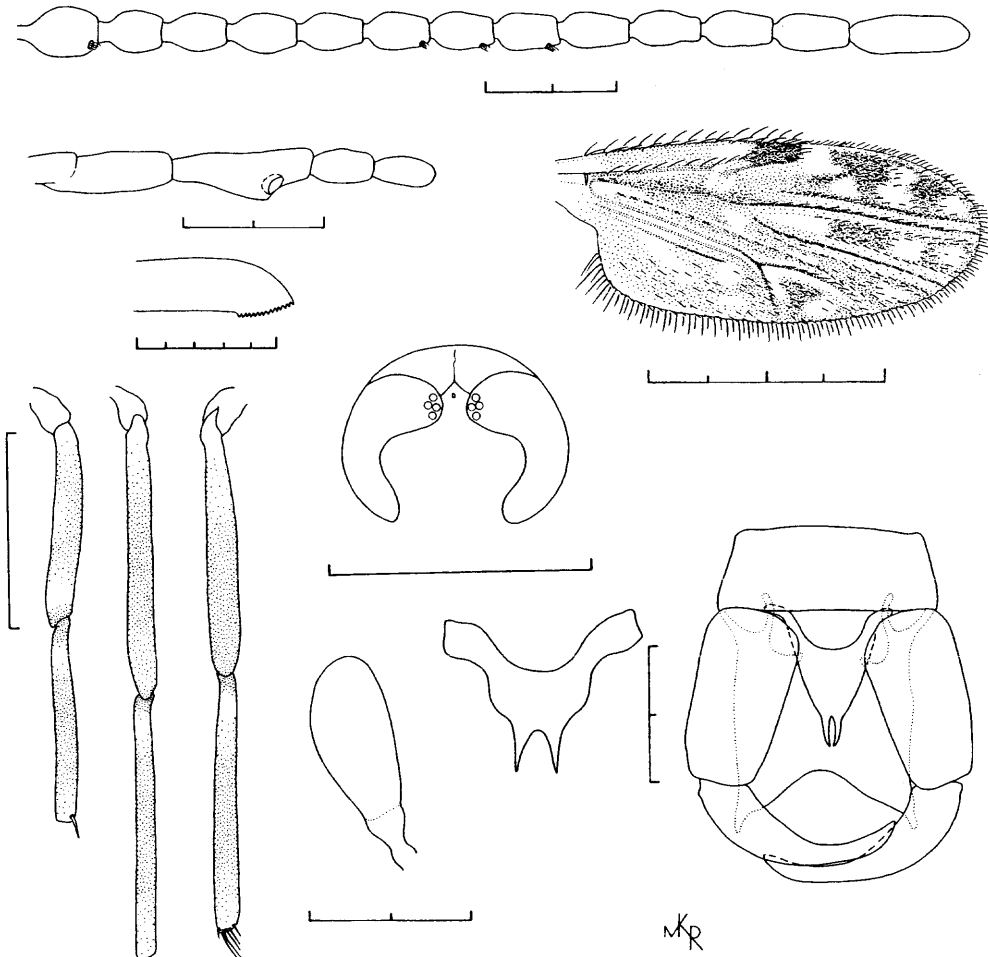


Fig. 9. *Culicoides (Monoculicoides) cornutus*. Adult female, male genitalia. (See key for scale.)

sal root long and slender; aedeagus with broad basal arch, distally bifid; parameres broadly fused basally, bifid distally, terminating in 2 slender distal processes.

**Kenya Species.** *C. cornutus* De Meillon.

***Culicoides (Monoculicoides) cornutus*  
De Meillon  
(Fig. 9)**

*Culicoides cornutus* De Meillon 1937: 332 (male, female, pupa). Holotype: ♀, Blackburn, Zululand, C. V. Meeser and F. Bayer, reared from pupa collected in an exposed muddy rainwater pool, 7-VIII-36. Cotype ♂♂, ♀♀, same data as holotype and Empangeni, Zululand, C. V. Meeser and F. Bayer, bred from pupae, some females biting in bright sunlight at midday, some males swarming near breeding pools in bright sunlight, 17-VII-36 (IMRJ).

**Diagnosis.** A very large, dark brown species. Female distal antennal segments short; sensilla coe-

loconica on segments 3, 8–10. Wing dark; 4 pale spots in cell R5, including a spot on anterior margin just distad of 2nd radial cell, another just below and distal to this spot, a double transverse pale spot in middle of cell, and a small pale spot at apex; cell M1 with an elongate pale spot at base and 2 rounded pale spots in distal portion; veins M1, M2, M3+4, and Cu1 broadly pale-margined; radial veins darkened. Female abdomen with saccate spermatheca. **Male Genitalia.** Aedeagus and parameres as in subgeneric diagnosis; apicolateral processes large and very broad, triangulate.

**Female.** Wing length 1.69 mm (1.30–1.96 mm,  $n = 6$ ). **Head.** Dark brown. Eyes very broadly separated by a distance equal to the diameter of about 3 ocular facets; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 18–12–13–13–14–14–14–14–15–15–14–15–25; A.R. 0.75 (0.70–0.85,  $n = 6$ ); sensilla coeloconica (with number per segment) on segments 3(1), 8(1), 9(1), 10(1). Third segment of maxillary palpus slender, with a small, rounded, shallow sensory pit; P.R. 3.17 (2.80–3.70,  $n = 6$ ). Proboscis long, P/H 0.88



(0.87–0.90,  $n = 6$ ); mandible with 14 teeth (12–15,  $n = 6$ ).

**Thorax.** Dark brown. Legs dark brown; femora pale basally, forefemur with a dorsal pale area at midlength and a subapical pale band; tibiae each with a subbasal pale band; hindtibial comb with 5 spines, 2nd from the spur longest, the 1st 2 spines nearly twice as long as the distal 3. Halter infuscated dark brown.

**Wing.** Macrotrichia sparse over most of wing. Wing pattern prominent, membrane infuscated brownish, with distinct, irregular pale spots and streaks; a small pale spot over r-m crossvein and a small irregular pale area on anterior margin above 1st radial cell; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell, a small pale spot just below and distal to the former, a transverse double pale spot at midlength either coalescing or separated, and a small pale spot at apex; cell M1 with an elongate pale spot at base, a small pale spot just past middle, and a 3rd pale spot at apex; cell M2 with irregular, elongate pale areas at base, just below median fork, and just above basal portion of vein M3+4, and a pale spot at apex of cell; cell M4 with a small pale spot in distal portion near posterior wing margin; anal cell with a large, ill-defined pale area in basal portion and a transverse double pale spot distally; veins M1, M2, M3+4, and proximal  $\frac{1}{2}$  of Cul broadly pale-margined; most of radial veins infuscated, giving appearance of a darkened stigma. Costal ratio 0.55 (0.54–0.56,  $n = 6$ ).

**Abdomen.** Dark brown. Spermatheca dark brown, elongate-ovoid to saccate, opening to duct moderately broad; spermatheca 0.091 by 0.050 mm (0.087–0.093 by 0.041–0.058 mm,  $n = 4$ ).

**Male Genitalia.** Ninth tergum with sides nearly straight, slightly flaring distally, apicolateral processes very large and broad, triangulate; caudal margin concave. Ninth sternum without caudo-median emargination; ventral membrane not spiculate. Basistyle only slightly tapering distally, dorsal root long and slender, ventral root short, with blunt apex; dististyle broad basally, abruptly curved at midlength, distally slender with bluntly pointed apex. Aedeagus with broad, moderately shallow basal arch, basal arms short and slender, laterally curved; distal median process tapering, apex deeply cleft, forming 2 slender, sharply pointed processes. Parameres broadly fused subbasally, forming a pair of very stout anterolateral lobes; distally bifid, terminating in 2 slender, apically pointed processes.

**Discussion.** Khamala & Kettle (1971) noted the similarity of *cornutus* to other species of the subgenus *Monoculicoides* but chose to retain it as the basis for the *cornutus* group.

**Bionomics.** The pupa was described and illustrated by De Meillon (1937). The larva of *cornutus* is undescribed.

The male type was reared from a pupa collected in an exposed muddy pool at Blackburn, Zululand

(De Meillon 1937). Walker & Davies (1971) found larvae in high concentrations breeding in a mixture of fine mud and dung surrounding cattle pens in Kenya and noted larvae also were associated with effluent ditches. Lubega & Khamala (1976) reared adults in Kenya from mud mixed with animal feces and from free water from puddles, slow-flowing streams, artificial drainage trenches, and water-filled concrete troughs for watering livestock. *C. cornutus* and *brucei* were the only species found in the aquatic system and the only ones in mud contaminated with animal feces. They noted that *cornutus* appears to favor any habitat with high organic matter content. In Zimbabwe, Braverman (1978) reared *cornutus* from mud samples taken at the edges of water bodies in the Salisbury area.

*Culicoides cornutus* has been collected in Kenya and Tanzania from savanna zones (Khamala 1971) and from high-altitude forest and grasslands, moist *Combretum* woodland and grassland, and semiarid *Acacia* woodland and grassland (Walker 1976). Walker & Davies (1971) noted that *cornutus* was a dominant species within the bluetongue enzootic area of Kenya and was found in especially dense, localized pockets near stock pens. Precipitin tests of blood-engorged females indicate *cornutus* feeds primarily on cattle and sheep (Walker & Davies 1971, Walker & Boreham 1976).

Walker & Davies (1971) established a laboratory colony of *cornutus* from about 500 wild-caught adults. Adult females were given blood meals on rabbits and allowed to oviposit on moist blotting paper pads. The larval substrate was a simulation of the natural habitat, but it never proved very successful; larval mortality usually exceeded 90%. Pupae were produced within 22 d; mean adult longevity was 10 d.

**Distribution.** Ethiopia, Kenya, South Africa, Tanzania, Zimbabwe.

**Material Examined.** ETHIOPIA: Addis Ababa, V. H. Lee home, 2,300 ft elev., V. H. Lee, light trap, 22–23-VIII-74, 1 ♀, 1 ♂. KENYA: Nairobi, Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 19-V-82, 1 ♀; same data, 1-VI-82, 1 ♀; Kabete, Dr. Davies' garden, C. L. Bailey, light trap and CO<sub>2</sub>, 20-V-82, 1 ♂. SOUTH AFRICA: Onderstepoort, no other data, 3 ♀♀, 3 ♂♂. ZIMBABWE: Salisbury, E. T. Reid, light trap, VIII-56, 1 ♀; same data, I-57, 1 ♀; Nkai region, Nkapi Dam, R. J. Phelps, truck trap, 23-III-81, 2 ♂♂.

#### Subgenus *Trithecodes* Wirth & Hubert

*Culicoides*, subgenus *Trithecodes* Wirth & Hubert 1959: 2. Type species: *Culicoides flaviscutatus* Wirth & Hubert (original designation).

**Diagnosis.** Female eyes broadly contiguous, without interfacetal setae. Female antenna with sensilla coeloconica usually on segments 3, 11–15. Third segment of maxillary palpus with sensilla scattered on distal surface. Hindtibial comb usually

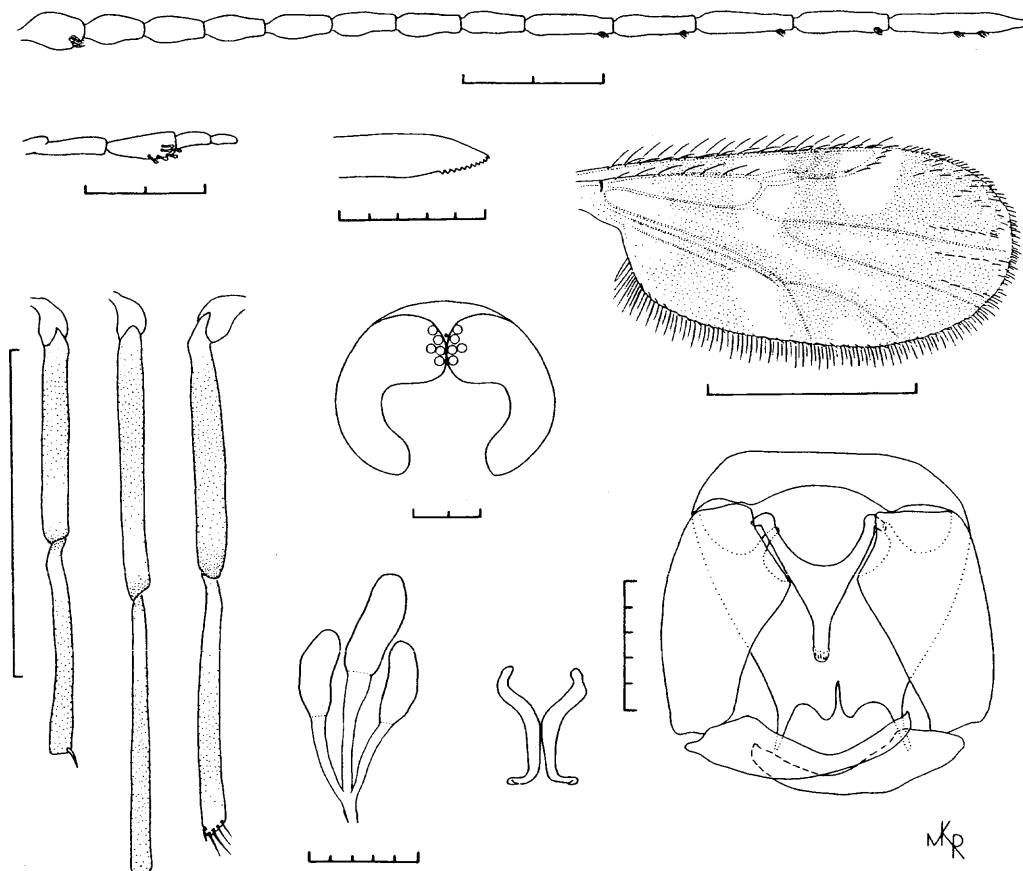


Fig. 10. *Culicoides (Trithecodes) fulvithorax*. Adult female, male genitalia. (See key for scale.)

with 4 spines. Wing with distinct pale spots over r-m crossvein and on anterior margin over apex of 2nd radial cell; large, distinct pale areas occasionally present over basal portion of wing and across wing apex, other pale areas usually indistinct; macrotrichia sparse, limited to wing apex and along vein M1. Female abdomen with 3 well-developed, sclerotized, functional spermathecae, shape variable from slightly pyriform with slender necks to sausage-shaped with unsclerotized ducts. **Male Genitalia.** Ninth tergum with well-developed apicolateral processes, caudal margin often deeply cleft or bilobed; basistyle with ventral root reduced, dorsal root slender; aedeagus usually with short basal arch, distal median process tapering to a simple apex; parameres separate, stem tapering to a simple, slender apex.

**Kenya Species.** *C. fulvithorax* (Austen).

***Culicoides (Trithecodes) fulvithorax* (Austen)**  
(Fig. 10)

*Johannseniella fulvithorax* Austen 1912: 105 (female). Holotype: ♀, Yala River, southern edge of Kakamega Forest, East Africa Protectorate, 4,800–5,300 ft, S. A. Neave, biting hand at light

(1930 hours), 21–28-V-11. Paratype: ♀, same data as holotype (BMNH).

*Culicoides fulvithorax* (Austen); Carter, Ingram & Macfie 1920: 230.

*Culicoides ochrothorax* Carter 1919: 298 (misident. by Carter et al. 1920, Colaco 1946, Khama-la & Kettle 1971, incorrect synonymy).

*Culicoides citrinus* Kieffer 1921: 15 (female). Types not saved, type locality Kribi, Cameroon; no other data.

*Culicoides ruficollis* Goetghebuer 1935b: 174 (male). Holotype: ♂, Rutshuru, Belgian Congo, Dr. De Wulf, I-34 (MRAC).

**Diagnosis.** A medium-sized species. Female proximal antennal segments elongate; sensilla coeloconica on segments 3, 11–15. Scutum and upper pleuron of thorax yellowish, scutellum yellowish brown, postscutellum and lower pleuron dark brown. Wing moderately infuscated, with 2 distinct pale spots over r-m crossvein and at anterior margin over distal portion of 2nd radial cell. Female abdomen with 3 functional spermathecae. **Male Genitalia.** Distal median process of aedeagus broad basally, tapering to a slender, rounded apex; stem of paramere slender, distally tapering to a simple, pointed apex.

**Female.** Wing length 1.00 mm (0.84–1.24 mm,  $n = 20$ ). **Head.** Brown. Eyes broadly contiguous for a distance equal to the diameter of 2 ocular facets; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 20–16–17–19–19–19–20–24–24–28–28–39; A.R. 0.97 (0.93–0.99,  $n = 20$ ); sensilla coeloconica (with number per segment) on segments 3(2–3), 11(1), 12(1), 13(1), 14(1–2), 15(1–2). Third segment of maxillary palpus moderately swollen, with sensilla scattered on distal surface; P.R. 2.51 (2.33–2.67,  $n = 12$ ). Proboscis moderately short, P/H 0.68 (0.61–0.75,  $n = 20$ ); mandible with 12 teeth (11–13,  $n = 19$ ).

**Thorax.** Scutum and upper pleuron yellowish, scutellum yellowish brown, postscutellum and lower pleuron dark brown. Legs brown; bases of femora pale, fore- and midfemora each with a broad subapical pale band; fore- and midtibiae each with a broad subbasal pale band, very weakly pale at apex; hindfemur with a weak subapical pale band, sometimes inapparent; hindtibia pale, broadly darker at middle; hindtibial comb with 4 spines, 2nd from the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined to apex of wing. Wing moderately infuscated, with only 2 distinct pale spots, including a large pale spot over the r-m crossvein extending to the costal margin, and a moderately large pale spot on the anterior margin over distal portion of the 2nd radial cell; wing base pale, pale areas in cell M4 and distal portion of anal cell usually indistinct; veins infuscated brownish. Costal ratio 0.67 (0.64–0.69,  $n = 20$ ).

**Abdomen.** Brown. Spermathecae light brown, variable in shape from saccate or elongate-ovoid to sausage-shaped, middle spermatheca larger than other two; openings of ducts broad, sclerotized ring present just below common junction of ducts; larger spermatheca 0.041 by 0.023 mm (0.030–0.048 by 0.018–0.028 mm,  $n = 15$ ), 2 smaller spermathecae subequal, each 0.036 by 0.017 mm (0.028–0.046 by 0.012–0.021 mm,  $n = 15$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, slender, pointed apicolateral processes; caudal margin deeply cleft at middle; 9th sternum with a shallow caudomedian emargination; ventral membrane not spiculate. Basistyle with a long, slender dorsal root with rounded apex, ventral root absent; dististyle broad basally, tapering to middle, distal portion moderately slender, curving, with pointed apex. Aedeagus with a broad, deep basal arch, basal arms slender; distal median process broad at base, tapering to a slender, rounded apex. Paramere without basal knob, curved just past base; stem moderately slender, tapering distally; distal portion bent laterally, often recurved, with simple, pointed apex.

**Discussion.** Wirth & Hubert (1959) proposed the *fulvithorax* group (one of six groups of the subgenus *Triethecoides*) for the Afrotropical species *fulvithorax* and *ochrothorax*. Characters of the group include: 9–11 mandibular teeth of subequal

length; spermathecae sausage-shaped, longer than broad, with broad unsclerotized duct entrances; ducts of all three spermathecae joined at one point near the sclerotized ring; and scutum yellowish. They noted that *ochrothorax* differs from *fulvithorax* in having curved mandibular teeth, the distal one pointing away from the others; the second palpal segment is much longer than the third; the spermathecae are shorter; and the hind femur is entirely dark. Kremer (1972b) agreed to the distinction between *fulvithorax* and *ochrothorax*, whereas Khamala & Kettle (1971) disagreed with Wirth & Hubert, confirming the synonymy of the two species made by Carter et al. (1920). Having not seen the type of *ochrothorax*, I prefer to keep the two species separate.

Wirth & Hubert (1959) preferred to leave *ruficollis* Goetghebuer (male) in the synonymy of *fulvithorax* (made by Colaco 1946), noting that it was impossible on the basis of the original description and illustration to determine where it belonged. Kremer et al. (1975) noted that the type of *ruficollis* had been lost during their work with the Goetghebuer types at Tervuren.

**Bionomics.** The immature stages of *fulvithorax* are undescribed.

*Culicoides fulvithorax* adults were reared from rotting banana and plantain stems in Cameroon (Hopkins 1952) and Gambia (Clastrier & Wirth 1961). Nicholas et al. (1953, 1955) reared *fulvithorax* from wet mud at the base of elephant grass, noting that breeding sites of this type were alternatives to banana and plantain stems.

In Nigeria, Dipeolu & Ogunrinade (1976) collected adults at Eruwa with emergence traps from boggy ground of a rocky hill site. At the University of Ibadan research farm, they (Dipeolu & Ogunrinade 1977) found adults most numerous in emergence traps placed along the margins of a dairy cattle drinking trough, in lower numbers from traps along an open drain leading from a slaughterhouse, and from a decomposing grass heap in the vicinity of livestock pens. Adults emerged throughout the year with peaks in June and August.

In East Africa, Khamala (1971) found *fulvithorax* to be primarily a forest species, but he also collected it in the savannas. Adults were second in relative abundance in light trap collections, making up about 12.6% of the *Culicoides* collected in a 2-yr survey. Walker (1976) collected *fulvithorax* in Kenya from moist *Combretum* woodland and grassland and from arid *Acacia-Commiphora* bushland. In Nigeria, Dipeolu (1976b) reported *fulvithorax* from all areas of Nigeria; it was most numerous in forests and least numerous on the plateau.

*Culicoides fulvithorax* females feed on a variety of animals, including humans. The female type was collected in Kenya while biting a man at the Yala River on the southern edge of the Kakamega Forest (Austen 1912). Nicholas (1953) reported it to be an important human-biter in its breeding areas in

Cameroon. De Meillon (1961) noted that *fulvithorax* females bite humans readily at night and that they appeared to bite cattle as well. In Ethiopia, White (1977) reported *fulvithorax* to be highly anthropophilic in the savanna lowlands adjacent to the Sudan, but apparently not so in the highlands. Females were most abundant from July to November and were predominantly crepuscular, biting indoors and outdoors with apparently equal avidity. He noted they were taken principally at Gambela on the Baro River and were probably widespread in such riverine habitats.

Braverman & Hulley (1979) found the host range of *fulvithorax*, based on precipitin tests of engorged females, to include horses and pigs. In Nigeria (Dipeolu et al. 1974, Dipeolu 1976b), *fulvithorax* was collected from near cattle and small ruminant pens in all regions. At the University of Ibadan research farm, it made up 1.4% of the light trap collections in a cattle paddock (43% blood fed), 4% of the population in a piggery (25% blood fed), and 3.3% in the sheep and goat paddocks (42% blood fed). Peak numbers of engorged females were collected from 0500 to 0700 hours. Females were collected near wild animal sites as well (Dipeolu 1976a), and it was the main species feeding on poultry in various areas of Nigeria (Dipeolu 1977).

*Culicoides fulvithorax* also is known to be entomophagous; Callot et al. (1968) reported one female taken on *Anopheles coustani* Lavarán in Madagascar.

**Distribution.** Angola, Cameroon, Congo, Ethiopia, Gambia, Ghana, Guinea, Ivory Coast, Kenya, Liberia, Madagascar, Nigeria, Senegal, Sudan, Tanzania, Uganda, Zaire, Zimbabwe.

**Material Examined.** ETHIOPIA: Kaffa Province, Buba Catholic Mission, about 4 km NE Wush-Wush, V. H. Lee, light trap, 18-20-V-74, 3 ♀♀; same data except light trap and CO<sub>2</sub>, 21-22-V-74, 3 ♂♂; Illubabor Province, Gambela, 1,748 ft, W. L. Schmitt, at light, XI-68, 1 ♀. GAMBIA: W. Kiang District, Keneba, D. H. Murphy, sticky trap, 1-VII-56, 2 ♀♀, 1 ♂; Sekuta, N. Kombo, D. H. Murphy, rotten banana stem, 20-X-59, 1 ♀. KENYA: Western Province, Kakamega Forest Reserve, Isechno, 500 m N Kakamega Forest Station, 100 m into forest along trail, 1,539 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 5-XI-81, 2 ♀♀. MADAGASCAR: Tamatave, Ivoloína, A. Grejbine, III-52, 2 ♀♀. ZAIRE: Coquilhatville, A. B. Stam, light trap, X-XI-62, 2 ♀♀; Gangala Na Bodio, near Mangava, Baker and Schmitt, 29-IV-55, 12 ♀♀ (3 plesiotypes); 75 mi E Kama, E. S. Ross and R. E. Leech, 16-VIII-57, 1 ♂. ZIMBABWE: Inyanga North, C. Green, 13-II-70, 1 ♀; Salisbury, E. T. Reid, light trap, X-56, 1 ♀.

#### *Culicoides albovenosus* Group

**Diagnosis.** Female eyes narrowly separated; distal antennal segments elongate; sensilla coeloconica

on antennal segments 3, 11-15; 3rd segment of maxillary palpus with a single, large, distal sensory pit. Hindtibiae comb with 4 spines. Wing with distinct pattern of pale spots, including large pale areas over r-m crossvein, in cell R5 on anterior margin extending over apex of 2nd radial cell, at wing base extending into proximal portion of anal cell, near apex of anal cell, and in distal portion of cell M4; prominent pale streaks over most of veins M1 and M2. Female abdomen with 2 functional spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with long, stout apicolateral processes; dorsal root of basistyle long, ventral root absent; aedeagus with broad distal median process; parameres separate, basal knob present, stem tapering to a laterally directed, simple apex.

**Kenya Species.** *C. albovenosus* Khamala & Kettle.

#### *Culicoides albovenosus* Khamala & Kettle (Fig. 11)

*Culicoides albovenosus* Khamala & Kettle 1971: 53 (male, female). Holotype: ♀, Zika Forest, Uganda, C. Khamala, light trap, 17-V-66 (BMNH). Paratypes: 1 ♀, 1 ♂, Kakamega Forest, Kenya, C. Khamala, light trap, 20-VIII-66(?) (BMNH); 18 ♀♀, Kawanda, Uganda, C. Khamala, light trap, 4-V-66 (1 ♀, BMNH; 2 ♀♀, USNM; 2 ♀♀, MRAC; 13 ♀♀, NMK).

**Diagnosis.** Similar to the group diagnosis. A moderately large, brownish species. Female distal antennal segments greatly elongated; 3rd segment of maxillary palpus with a large, shallow sensory pit. Wing pattern as in group diagnosis; cell M2 with a diffuse pale area at midlength. **Male Genitalia.** Distal median process of aedeagus broad, apex truncate.

**Female.** Wing length 1.19-1.36 mm ( $n = 3$ ). **Head.** Brown. Eyes very narrowly separated, almost contiguous; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 21-14-15-15-15-15-16-16-28-29-33-32-47; A.R. 1.33-1.56 ( $n = 2$ ); sensilla coeloconica (with number per segment) on antennal segments 3(2-3), 11(1), 12(1), 13(1), 14(2), 15(3-4). Third segment of maxillary palpus greatly expanded, with a large, rounded, shallow distal sensory pit; P.R. 1.82-1.90 ( $n = 3$ ). Proboscis short, P/H 0.61; mandible with 11-13 teeth ( $n = 3$ ).

**Thorax.** Brown. Legs brown, knees narrowly darker; femora pale basally and apically; tibiae pale basally; hindtibiae comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse over distal ½ of wing and in anal cell. Wing with a large, prominent pale spot over r-m crossvein, extending anteriorly to costal margin and caudally into cell M2; a large pale spot in cell R5 on anterior margin, extending over apex of 2nd radial cell; large pale spots in

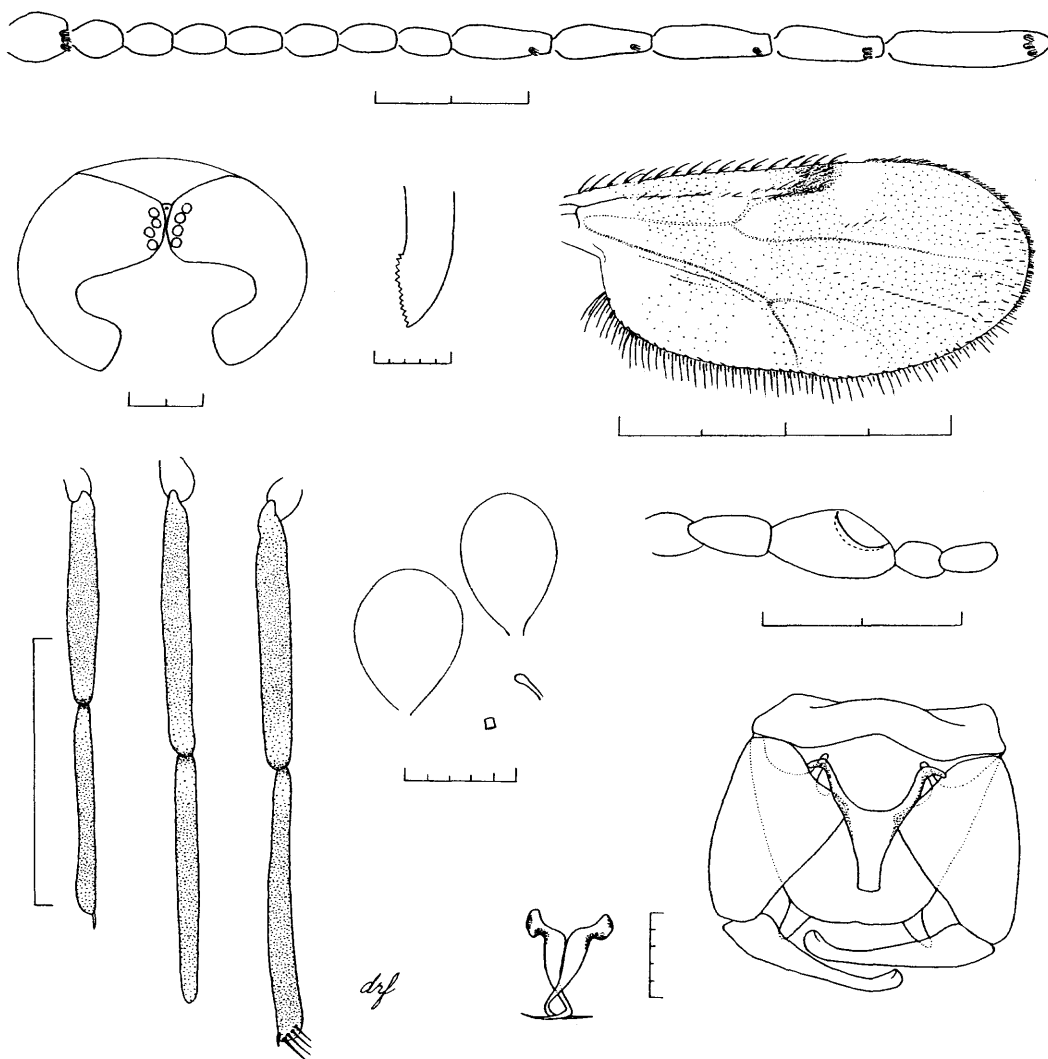


Fig. 11. *Culicoides albovenosus* (*albovenosus* group). Adult female, male genitalia. (See key for scale.)

distal portion of cell M4 and distal portion of anal cell; broad pale area at wing base, extending from costal margin to basal portion of anal cell; cell M2 with a diffuse pale area at midlength; cell M1 with a short pale area near base, proximal to vein M2; prominent pale streaks over distal  $\frac{2}{3}$  of veins M1 and M2. Costal ratio 0.58–0.61 ( $n = 3$ ).

**Abdomen.** Brown. Spermathecae dark brown, slightly unequal, ovoid, without sclerotized necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.060–0.064 by 0.048 mm ( $n = 3$ ) and 0.058–0.062 by 0.043–0.044 mm ( $n = 3$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, stout apicolateral processes. Ninth sternum with a moderately shallow caudomedian emargination; ventral membrane not spiculate. Basistyle very broad, tapering distally; dorsal root long and moderately slender, ventral root absent; dis-

tistyle nearly straight, distally tapering to a slightly curved, bluntly pointed apex. Aedeagus with a deep, rounded basal arch; lateral arms slender, curving laterally at bases; distal median process broad, tapering to a stout, truncate apex. Paramere with prominent, anterolaterally directed basal knob; stem stout over basal  $\frac{1}{2}$ , distally tapering to a slender, laterally directed, pointed apex.

**Discussion.** Khamala & Kettle (1971) apparently were unaware of the description of *angolensis* Caeiro (1961) when they described *albovenosus*. Comparison of two Uganda female paratypes of *albovenosus* with descriptions and illustrations of *angolensis* shows these two species to be probably synonymous (types of *angolensis* were not available for study). The female specimen of *albovenosus* collected in Kabete, Kenya, has very pale legs and pale proximal antennal segments and may be *neoangolensis* Kremer.

**Bionomics.** The immature stages and larval habitat of *Culicoides albovenosus* are undescribed.

In East Africa, Khamala (1971) collected adults by light trap from forested areas (Kakamega Forest, Kenya; Zika Forest, Uganda) and from a savannalike zone derived from forest (Uganda). The feeding habits of *albovenosus* are unknown, although the low number of antennal sensilla indicate it probably feeds on larger mammals.

**Distribution.** Kenya, Uganda.

**Material Examined.** KENYA: Kakamega Forest, C. Khamala, light trap, 26-V-66, 1 ♂ paratype; Nairobi Province, Nairobi, Kabete, Dr. Davies' garden, C. L. Bailey and Kairo, light trap and CO<sub>2</sub>, 28-V-82, 1 ♀. UGANDA: Kawanda, C. Khamala, light trap, 4-V-66, 2 ♀♀ paratypes.

### *Culicoides imicola* Group

**Diagnosis.** Female eyes contiguous. Female antenna with sensilla coeloconica usually on segments 3, 11–15. Hindtibial comb usually with 5 spines. Wing with faint to prominent pale markings; 2nd radial cell ending in a pale spot or dark to apex; macrotrichia sparse. Female abdomen with 2 ovoid, functional spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum usually rounded caudally, apicolateral processes absent or short and stout; basistyle with dorsal and ventral roots long and simple; aedeagus usually with a basal sclerotized membrane connecting the lateral arms, distal median process with rounded apex and usually with a subapical, anteriorly directed process; parameres separate, tapering distally to a slender, bare or microscopically setose apex.

**Kenya Species.** *C. gulbenkiani* Caeiro, *C. imicola* Kieffer, *C. kanagai* Khamala & Kettle, *C. kibatiensis* Goetghebuer, *C. pseudopallidipennis* Clastrier, *C. spinifer* Khamala & Kettle, *C. trifasciellus* Goetghebuer.

### *Culicoides gulbenkiani* Caeiro

(Fig. 12)

*Culicoides gulbenkiani* Caeiro 1959: 155 (male, female). Types: 15 ♀♀, Onderstepoort, South Africa, 20-III–30-IV-58; 3 ♀♀, 1 ♂, same data, IV-56(?) (as *milnei*) (VRIO?).

*Culicoides tororoensis* Khamala & Kettle 1971: 48 (male, female). Holotype: ♀, Tororo, Uganda, C. Khamala, light trap, 12-VI-66 (BMNH). Paratypes: 2 ♀♀, same data as holotype (1 ♀, USNM; 1 ♀, MRAC); 1 ♀, 1 ♂, Nairobi, Kenya, C. Khamala, light trap, 7-VII-66 (1 ♀, NMK; 1 ♂, BMNH); 1 ♀, Nakuru, Kenya, C. Khamala, light trap, 23-XI-66 (NMK); 1 ♂, Amani, Tanzania, C. Khamala, light trap, 16-V-67 (USNM).

**Diagnosis.** A medium-sized, dark brown species. Female proximal antennal segments moderately elongated; 3rd segment of maxillary palpus slender, with a small, shallow sensory pit; proboscis

long. Wing pattern moderately distinct; 2nd radial cell dark to apex; cell R5 with a large, rounded pale spot on anterior margin just distad of 2nd radial cell, a large pale spot just past middle of cell extending to anterior wing margin, and a small pale spot at apex; other cells extensively pale, markings less distinct. **Male Genitalia.** Ninth tergum with caudal margin nearly straight, and with shallow median emargination; distal median process of aedeagus long and stout, apex rounded; apex of paramere bare; dististyles stout, strongly curved at midlength.

**Female.** Wing length 0.92–0.99 mm ( $n = 2$ ). **Head.** Dark brown. Eyes contiguous for a distance equal to diameter of about 1.5 ocular facets; without interfacetal setae. Antenna with flagellar lengths in proportion of 18–13–13–14–14–14–15–16–21–21–20–20–31; A.R. 0.97–1.00 ( $n = 2$ ); sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(1), 15(1). Third segment of maxillary palpus moderately slender, with a rounded, shallow sensory pit; P.R. 2.56–2.73 ( $n = 2$ ). Proboscis long, P/H 0.97–1.00 ( $n = 2$ ); mandible with 15 teeth.

**Thorax.** Dark brown. Legs dark brown, forelegs paler; femora pale basally, fore- and midfemora paler subapically; tibiae each with a subbasal pale band, hindtibia paler at apex; hindtibial comb with 5 spines, that nearest the spur very large, much longer and stouter than the other 4. Halter pale.

**Wing.** Macrotrichia absent except for several next to margin at wing apex. Wing pattern moderately distinct; 2nd radial cell dark to apex, stigmal area dark brown; wing membrane infuscated pale grayish brown, darker near anterior margin; wing with numerous pale spots and streaks, including a round pale spot over r-m crossvein, coalescing with a short pale streak just above on anterior margin; cell R5 with a large, rounded pale spot on anterior margin just distad of 2nd radial cell, a large, irregular, transverse pale spot just past middle extending to anterior wing margin, and a small spot at apex; cell M1 with a pale area at base and in middle coalescing with a broad pale streak over most of vein M1, and a small pale spot at apex; cell M2 with a broad pale streak almost entirely filling cell, coalescing with a small pale spot at apex; cell M4 with pale spot in distal ½, extending to wing margin; anal cell with a series of large, irregular pale areas, coalescing and filling almost entire cell; wing veins infuscated very pale brown. Costal ratio 0.55.

**Abdomen.** Dark brown. Spermathecae very unequal, ovoid, with short, tapering, sclerotized necks; rudimentary 3rd moderately long; sclerotized ring short; functional spermathecae 0.064 by 0.048 and 0.048 by 0.039 mm.

**Male Genitalia.** Ninth tergum broad, sides nearly parallel; caudal margin nearly straight, with a shallow median emargination; 9th sternum with a broad, deep caudomedian emargination, ventral membrane not spiculate. Basistyle with dorsal and

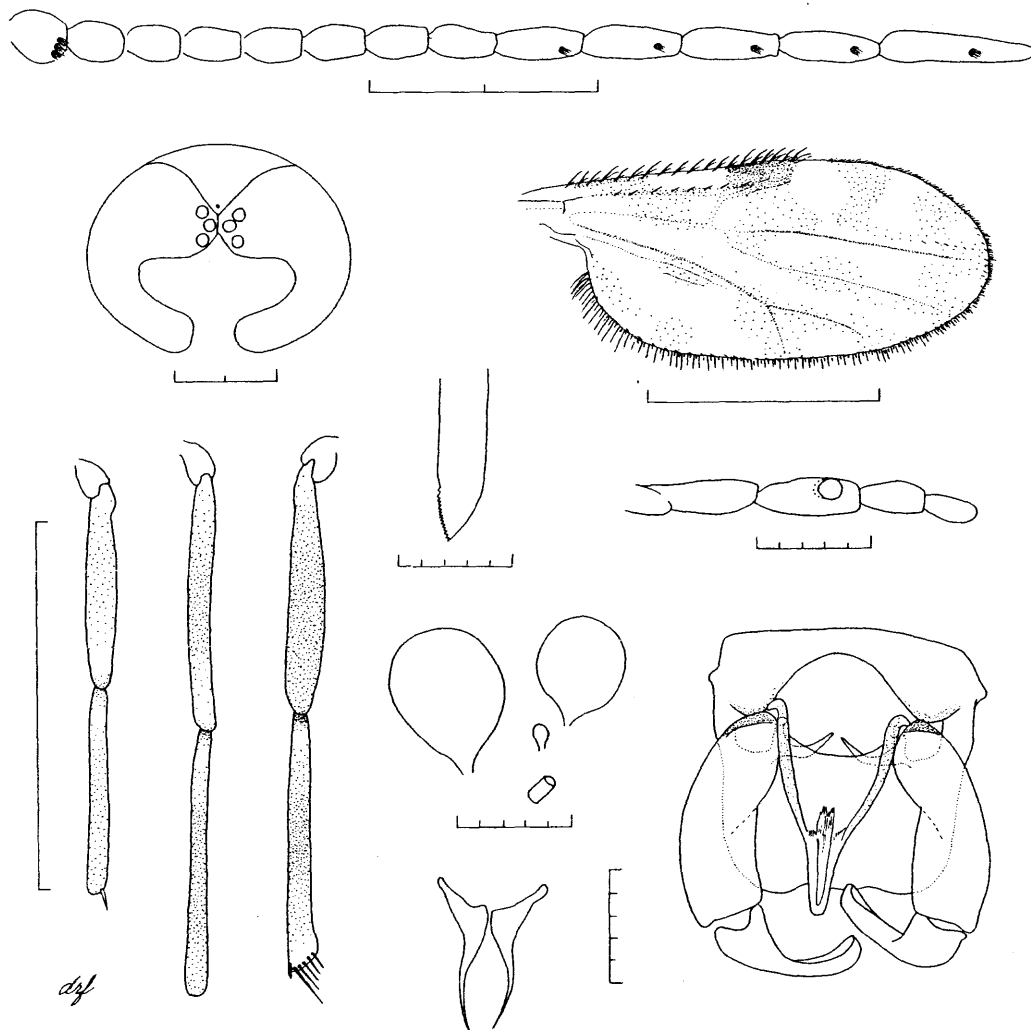


Fig. 12. *Culicoides gulbenkiani* (*imicola* group). Adult female, male genitalia. (See key for scale.)

ventral roots long and slender, dorsal root curved mesally at apex; dististyle stout, strongly curved at midlength, distally expanded, with bluntly pointed apex. Aedeagus with a moderately shallow basal arch, lateral arms slender, directed laterally at bases; sides of aedeagus tapering to a long, stout distal process, extending past caudal margin of 9th tergum, apex rounded; aedeagus with a short, stout, anteriorly directed subapical process. Paramere stout basally, produced anterolaterally into a slender process; stem tapering to a very slender, curving filament, apex bare.

**Discussion.** The hindtibial comb and wing macrotrichia of *gulbenkiani* is typical of the *trifasciellus* subgroup; however, the male parameres do not appear to have setose apices. Cornet (personal communication) does not place *gulbenkiani* in the *trifasciellus* subgroup.

Although Khamala & Kettle (1971) described and illustrated the ninth sternum of the male as

spiculate and the apices of the parameres as setose, these characters were not observed in the male paratype of *tororoensis* from Kenya in the BMNH, in the male paratype from Tanzania in the USNM, or in three males from Zimbabwe. These characters were not found in Caeiro's (1959) original description and illustration of *gulbenkiani*.

**Bionomics.** The immature stages of *gulbenkiani* are undescribed.

In Kenya, Lubega & Khamala (1976) reared adults (as *tororoensis* n. sp.) from water-logged mud of freshwater marshes overgrown with *Cyperus* and *Typha*. Braverman (1978) reared *gulbenkiani* in the Salisbury area of Zimbabwe predominantly from cow dung on damp soil. He considered it a true cow dung breeder because it was the only species recovered mainly from dung. Several adults also were reared from mud, poor in organic matter, taken along streams and drainage canals.

In East Africa, Khamala (1971) collected large numbers of adults (as *tororoensis* n. sp.) by light trap from a savanna in Uganda. In Kenya, Walker (1976) collected adults (as *tororoensis*) from high altitude forests and grasslands, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

In South Africa, Nevill & Anderson (1972) showed by precipitin tests of engorged females that *gulbenkiani* feeds either on horses or cattle. Walker & Davies (1971) found *gulbenkiani* (as sp. 23) to be a dominant species within the bluetongue enzootic area of Kenya but to have a lower vector potential than *imicola* and others. Precipitin tests of seven blood-engorged females gave one positive for sheep. They isolated bluetongue-1 virus from *gulbenkiani* in February and Nairobi sheep disease virus from a pool in November.

**Distribution.** Kenya, South Africa, Tanzania, Uganda, Zimbabwe.

**Material Examined.** SOUTH AFRICA: Merri-vale District, Pietermaritzburg, B. Stuckenberg, light trap, V-80, 1 ♂. TANZANIA: Amani, C. Khamala, light trap, 16-V-67, 1 ♂ paratype (as *tororoensis*). UGANDA: Tororo (EATRO), C. Khamala, light trap, 12-VI-66, 1 ♀ paratype (as *tororoensis*). ZIMBABWE: Sinamwenda, P. Gaddie, II-III-70, 1 ♀, 2 ♂♂; Magondi Reserve, C. Green, 14-II-70, 1 ♂.

### *Culicoides imicola* Kieffer (Fig. 13)

*Culicoides imicola* Kieffer 1913: 11 (female). Holotype: ♀ no. 5K, Tiwi, British East Africa, 20 km S Mombasa (station no. 5), 3-XI-11 (MHNP).

*Culicoides pallidipennis* Carter, Ingram & Macfie 1920: 265 (male, female). Types: Accra, Gold Coast, on laboratory windows, XII-19-IV-20 (BMNH, MRAC).

*Culicoides minutus* Sen & Das Gupta 1959: 622 (female). Holotype: ♀, DumDum, India, S. K. Das Gupta, light trap, II-57 (PCC).

*Culicoides pseudoturgidus* Das Gupta 1962: 538 (female only). Holotype: ♀, DumDum, India, S. K. Das Gupta, light trap, VII-60 (PCC). Paratypes: 1 ♀, Thakurpukur, India, S. K. Das Gupta, sticky trap, X-60; 1 ♀, DumDum, India, S. K. Das Gupta, sticky trap, VIII-60 (USNM).

**Diagnosis.** A medium-sized, dark brown species. Female with 3rd segment of maxillary palpus slender, with a moderately large, rounded, shallow sensory pit. Wing with numerous, prominent pale markings, including large pale spots over r-m crossvein, just distad of 2nd radial cell, and at apex of cell R5; vein M1 with a pale streak over distal ½; M1, M2, M4, and anal cells extensively pale. **Male Genitalia.** Ninth tergum broadly rounded caudally, with shallow median emargination; distal median process of aedeagus slender; apices of parameres bare.

**Female.** Wing length 0.90 mm (0.80–1.12 mm,  $n = 16$ ). **Head.** Dark brown. Eyes contiguous for a distance equal to diameter of about 1.5–2 ocular facets; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 16–12–12–13–13–13–13–14–18–20–20–22–31; A.R. 1.05 (0.95–1.13,  $n = 15$ ); sensilla coeloconica (with number per segment) on segments 3(1), 12(1), 13(1), 14(1), 15(1). Third segment of maxillary palpus slender, with a moderately large, rounded, shallow sensory pit; P.R. 2.56 (2.41–2.69,  $n = 16$ ). Proboscis moderately long, P/H 0.87 (0.78–0.93,  $n = 16$ ); mandible with 14 teeth (12–16,  $n = 16$ ).

**Thorax.** Dark brown. Legs brown; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a narrow subbasal pale band, hindtibia broadly pale at apex; hindtibial comb with 5 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined to wing apex. Wing with numerous, prominent pale markings, including a large pale spot over r-m crossvein extending to costal margin, a large pale spot on anterior margin just distad of 2nd radial cell, and a large pale area at apex of cell R5; vein M1 with a broad pale streak covering distal ¾ of vein; cell M1 with an elongate pale spot near base and a large pale spot near middle of cell, narrowing as a pale streak to margin, forming 2 separate dark areas proximal to vein M2; cell M2 extensively pale throughout most of cell; cell M4 with a large pale spot filling distal ¾; anal cell extensively pale at base, coalescing at middle with a large, irregular pale area in distal portion; membrane between the pale markings infuscated pale grayish brown. Costal ratio 0.56 (0.53–0.58,  $n = 16$ ).

**Abdomen.** Brown. Spermathecae unequal, ovoid, with short sclerotized necks; rudimentary 3rd narrow; sclerotized ring moderately long; functional spermathecae 0.050 by 0.039 mm (0.042–0.058 by 0.035–0.043 mm,  $n = 13$ ) and 0.041 by 0.032 mm (0.036–0.046 by 0.028–0.036 mm,  $n = 13$ ).

**Male Genitalia.** Ninth tergum with nearly parallel sides, broadly rounded caudally with a shallow median emargination. Ninth sternum with a broad, deep caudomedian emargination; ventral membrane spiculate. Dorsal and ventral roots of basistyle long and slender with pointed apices, dorsal root curved mesally; dististyle moderately stout, curved, apex bluntly pointed. Aedeagus with a moderately deep basal arch, lateral arms slender, with short, laterally directed bases; sides of aedeagus tapering to a slender, apically rounded distal process; base of distal median process with a long, stout, anteriorly directed subapical process. Paramere with stout, anterolaterally directed base; main stem slender, sickles shaped, tapering distally to a pointed, bare apex.

**Discussion.** Kremer (1972b) first suggested the synonymy of *pallidipennis* Carter, Ingram & Macfie with *imicola* after studying Kieffer's female type at the Paris Museum. Khamala & Kettle's (1971)



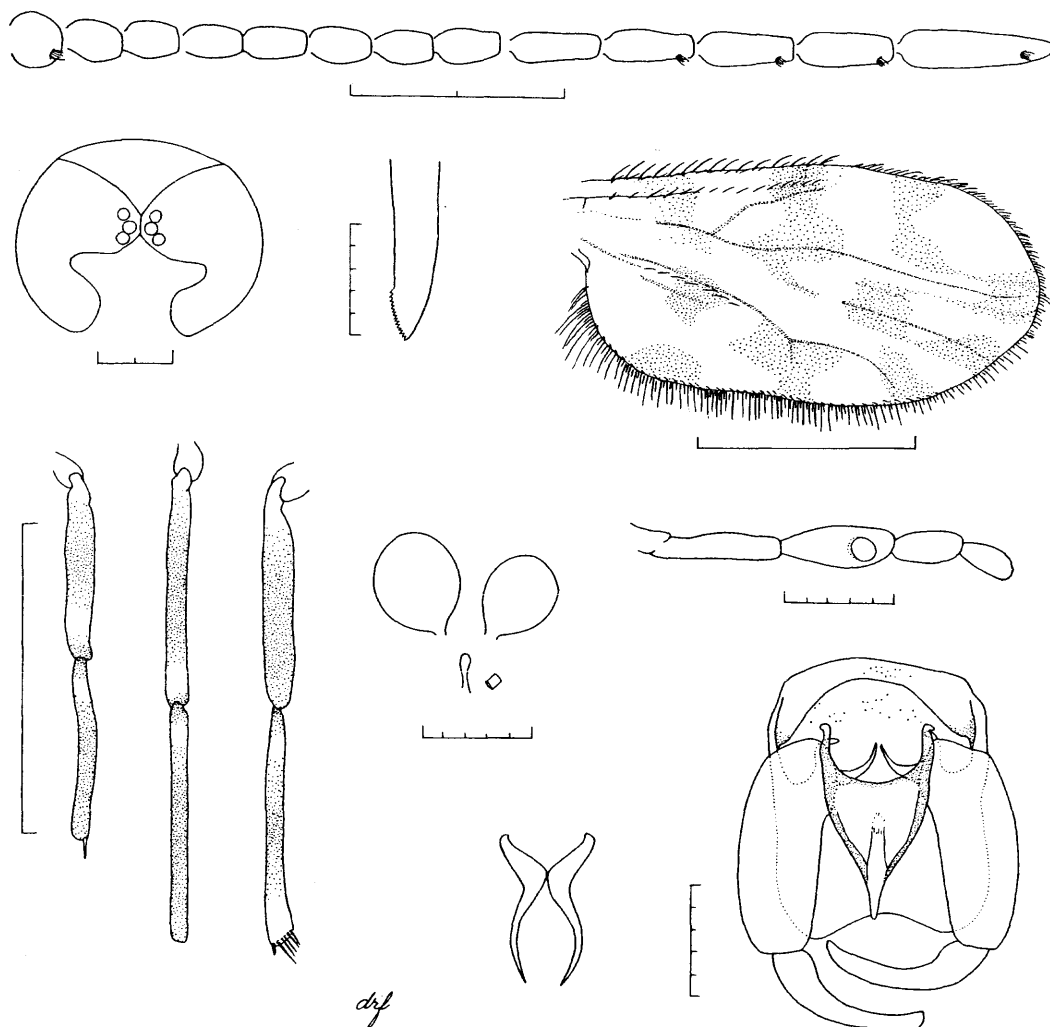


Fig. 13. *Culicoides imicola* (*imicola* group). Adult female, male genitalia. (See key for scale.)

*pallidipennis* is not true *imicola*; their description and wing illustration may be of *pseudopallidipennis*, although they may also have collected *imicola* males, because they describe the ninth sternum as spiculate.

*Culicoides glabripennis* Goetghebuer is not a synonym of *imicola* as stated by Khamala & Kettle (1971) but is very similar to *grahamii* Austen; *glabripennis* has an antennal sensory pattern of 3, 12–15, whereas *grahamii* has a sensory pattern of 3, 11–15 and the macrotrichia are more abundant on the wing of *glabripennis*. The male of *glabripennis* has a bare ninth sternum, whereas in *grahamii* the membrane of the ninth sternum is spiculate. It is difficult to say exactly what Khamala and Kettle's *grahamii* is because of the incomplete description of the female (likewise of *grahamii* sensu Dipeolu, and Lubega & Khamala).

Khalaf (1961) synonymized *iraqensis*, previously known only from the male (Khalaf 1957), with *imicola* (as *pallidipennis*), after collecting females

of *iraqensis* in Iraq; however, his illustration of the wing of *iraqensis* is clearly not that of *imicola*.

Cornet (personal communication to Braverman) (in Braverman 1978) showed that Nevill's *imicola* (as *pallidipennis*) reared from dry cow pats at Onderstepoort, South Africa in 1968 was actually that of a closely related species, *C. 1348* (= *pseudopallidipennis*?). His description and illustration of the fourth instar and pupa from the South African material (Nevill 1969) also would then not be of *imicola*.

Dyce & Wirth (1983) placed the Indian species *Culicoides minutus* Sen & Das Gupta and *C. pseudoturgidus* Das Gupta as junior synonyms of *imicola* after studying type material from the Presidency College, University of Calcutta, and the USNM.

**Bionomics.** The immature stages of *imicola* are undescribed. Nevill's (1969) material from South Africa needs further study.

The larvae of *imicola* have been found in a num-

ber of different habitats; however, in view of the confusion with closely related species of the group, rearing records should be regarded with caution.

Hopkins (1952) reared adults (as *pallidipennis*) from rotting banana and plantain stems in Cameroon. Clastrier & Wirth (1961) reported (as *pallidipennis*) two males from a banana stump and one female from moist, sandy soil near a well in Gambia.

In Kenya, Walker & Davies (1971) found high concentrations of larvae in the fine mixture of mud and dung surrounding cattle pens and in associated effluent ditches. Adults dispersed up to distances of 500 m from this habitat. Lubega & Khamala (1976) reared *imicola* (as *pallidipennis*) from drying cow pats in open grassland (*pseudopallidipennis*?); from mud at the edges of freshwater fish ponds; and in soil lying beneath cut, drying grass.

In Zimbabwe, Braverman (1978) reared *imicola* from mud samples taken at the edges of bodies of water and along drainage canals; adults also were reared from cow dung, especially over wet soil.

In Nigeria, Dipeolu & Ogunrinade (1976) found *imicola* to be abundant at a rocky hill site at Eruwa and at the Opeki River. Adults emerged from boggy ground at the hill site and from natural or artificial holes and rotting vegetation along the river bank. At the University of Ibadan research farm (Dipeolu 1977, Dipeolu & Ogunrinade 1977), *imicola* (?) was found predominantly in cattle dung; adults were collected from emergence traps at the margins of a cattle drinking trough, along an open drain leading from a slaughterhouse, and from decomposing grass near livestock pens. It was the most numerous species collected (32%), emerging throughout the year with peaks in June and August.

Braverman et al. (1974) found *imicola* (as *pallidipennis*) breeding in Israel in rich mixtures of organic matter and water-saturated soils (not requiring surface water). It also was noted (Braverman & Galun 1973b) that drainage canals, sewage pipes, and puddles from leaking irrigation systems were important as transient breeding sites in the dry summer season, helping to maintain populations throughout the year.

Walker & Davies (1971) reported that *imicola* (as *pallidipennis*) is a dominant and widespread species in the bluetongue enzootic area of Kenya, with evidence that the adults concentrated around sheep. Khamala (1971) noted that it made up about 11% of the total *Culicoides* collected in a 2-yr light trap study in East Africa (Kenya, Tanzania, Uganda) and was third in relative abundance. Adults were widely distributed in forests and savannas. Walker (1976) collected adults from high-altitude forests and grasslands, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

Clastrier & Wirth (1961) recorded adults (as *pallidipennis*) taken at light in Nigeria during October, December, January, and February. Dipeolu

(1976b) collected *imicola* throughout Nigeria around cattle and small ruminant pens. It was the second most abundant *Culicoides* species collected (17.8%), being a predominant species in the forest and Sudan zones and was second in abundance in derived savanna and Guinea zones.

In Zimbabwe, Braverman (1978) found *imicola* to be common in suction light trap catches in animal enclosures in the Salisbury area throughout the year, being the dominant species toward the end of the rainy season and throughout the dry season. Adults were reared from breeding sites in January to May and in November and December. Pupae collected in the cold season (May–August) developed mainly from eggs laid at the end of the rainy season (April).

In Israel, *imicola* (as *pallidipennis*) is a widespread species and has been collected by light trap from sheep folds throughout the year (Callot et al. 1969, Braverman & Galun 1973b, Braverman et al. 1976). Light trap collections at a sheep pen at Bet Dagan showed a small peak in March and a larger peak from August to November (Braverman & Galun 1973b).

The host range of *imicola*, based on precipitin tests of blood-engorged females, includes cattle, horse, sheep, and poultry with a preference for cattle (Walker & Davies 1971, Nevill & Anderson 1972, Walker & Boreham 1976). Braverman et al. (1977) noted that of 18 females tested, only three had taken an avian blood meal. Clastrier & Wirth (1961) recorded one female (as *pallidipennis*) biting cattle in December and adults on a sticky trap near cattle at Keneba, Gambia. In Nigeria, Dipeolu et al. (1974) found *imicola* (as *pallidipennis*) to be one of the predominant species in the cattle paddock at the University of Ibadan research farm, making up 18% of the *Culicoides* population (28% blood fed); it also was taken in a piggery (7.4% of the population, 33% blood fed) and in sheep and goat paddocks (8.7% of the population, 31% blood fed). It was the predominant species where wild animals were kept, accounting for 36.9% of the total *Culicoides* (44.1% blood fed) (Dipeolu 1976a). Females also were found to feed on poultry, as shown by testing engorged females trapped from near poultry houses in Nigeria (Dipeolu 1976b).

In South Africa (Nevill & Anderson 1972), precipitin tests of blood-fed *imicola* females (as *pallidipennis*) were positive only for mammalian antisera, chiefly cattle and horses and (at least one positive test) sheep. It accounted for more than 94% of the light trap catches near mules, sheep, and cattle, compared with only 47.1% near poultry and 26.2% in a control trap (garden). Significantly more engorged females were collected by light trap near cattle than near mules, sheep, or poultry.

Walker (1977) found *imicola* (as *pallidipennis*) to be the most important species (with *schultzei*) in relation to the epidemiology of bluetongue virus in Kenya. It was widespread, occasionally occurring in large numbers even in hot, dry areas. Fe-

males showed a strong preference for cattle but would feed on sheep and goats even when cattle were available.

In Israel, *imicola* has a wide host range, preferring to feed on large mammals such as cattle, horses, and sheep (Braverman & Rubina 1976). It also is considered second in importance as a potential vector of pathogens to poultry because of the large number of blood-engorged females shown positive by precipitin tests for avian blood.

**Medical Importance.** DuToit (1944) incriminated *imicola* (as *pallidipennis*) in South Africa as a vector of African horse sickness and was able to infect sheep with bluetongue virus by means of field-collected adults.

*Culicoides imicola* is the presumptive vector of bluetongue virus in Kenya (Davies & Walker 1974) and in South Africa (Bailly-Choumara & Kremer 1970). Isolations of bluetongue 1 and bluetongue 4 were made in Kenya on three occasions (Walker & Davies 1971, Walker 1977), and Palyam group viruses were isolated from pools in which *imicola* was a predominant species (Walker 1977). In Nigeria, Lee (1979) made isolations of Sabo virus and Shamonda virus (Simbu group) from unfed *imicola* (as *pallidipennis*) during the course of viral surveillance at the University of Ibadan research farm. Bluetongue virus was isolated from mixed *Culicoides* pools in which *imicola* was one of the most abundant species.

In Israel, *imicola* is the dominant species in association with sheep and has been collected in localities where disease has occurred (Braverman & Galun 1973b). Bluetongue is prevalent mainly in the north where *Culicoides* breeding sites are more plentiful; several strains of bluetongue have been isolated from pools of *imicola* or from pools consisting mainly of *schultzei* group and *imicola* from many localities (Braverman et al. 1981).

**Distribution.** Algeria, Angola, Cameroon, Chad, Congo, Cyprus, Egypt, Ethiopia, France, Gambia, Ghana, Guinea, India, Iran, Iraq, Israel, Ivory Coast, Kenya, Madagascar, Mauritius, Morocco, Nigeria, Reunion, São Tomé, Senegal, South Africa, Spain, Sudan, Syria, Tanzania, Turkey, Uganda, Upper Volta, Zaire, Zimbabwe.

**Material Examined.** CHAD: Boumkabio Moyer Chari, biting man at 1800 hours, J. C. Hitchcock, 6-IV-66, 1 ♀. EGYPT: Behiera Governorate, 29-VI-73, 1 ♀. ETHIOPIA: Illubabor Province, Gambela, 1,750 ft elev., B. McMillan, light trap, 25-26-VI-74, 1 ♀; Gila River Mission Station, W. L. Schmitt, light trap, II-70, 2 ♀♀. GAMBIA: West Kiang District, Keneba, D. H. Murphy, sticky trap, 1-VI-56, 1 ♀, 1 ♂. ISRAEL: Bét Dagan, sheep fold, B. Zilber, 29-VIII-67, 3 ♀♀; same data, 31-VIII-67, 4 ♀♀; same data, 18-XI-67, 3 ♀♀; same data except A. Zaike, 20-IX-67, 2 ♀♀; Neve Yaar, sheep fold, Shimshoni, 8-XI-65, 1 ♀; same data, 2-VIII-66, 1 ♀. KENYA: Nairobi Province, Nairobi, Karen, Rees Barn, Mbagathi River, 1,800 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 29-X-81, 2 ♀♀; same

locality except Karen, 800 m W Karen Rd., 1,000 m S of Bongani Rd., N fork Mbagathi River, Noad Farm, 1,650 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 4-XII-81, 1 ♂; same locality except Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 19-V-82, 3 ♀♀; same data, 22-V-82, 1 ♀; same data, 25-V-82, 1 ♀. MAURITIUS: Roches Noires, 8-VII-69, 1 ♀. NIGERIA: Kankiya, B. McMillan, light trap, XII-55, 1 ♂; same data, I-57, 1 ♀, 1 ♂; same data, II-57, 13 ♀♀, 15 ♂♂. ZIMBABWE: Kariba, 1,675 ft elev., D. R. Birkenmeyer, blacklight trap, 20-X-67, 2 ♀♀; same data, 26-X-67, 1 ♀; same data, 6-II-68, 2 ♀♀; Salisbury, E. T. Reid, light trap, III-56, 1 ♀; same data, 30-V-56, 1 ♀; same data, IX-56, 2 ♂♂; same data, X-56, 2 ♀♀, 1 ♂; same data, IV-57, 1 ♀, 1 ♂; same data, VI-57, 1 ♂; same data, VIII-57, 4 ♀♀, 4 ♂♂; Nkai region, Goodwood Ranch, R. J. Phelps, truck trap, 22-III-81, 1 ♂; same locality except Wynhill Farm, R. J. Phelps, 12-V-81, 1 ♀; Magondi Reserve, C. Green, 3-II-70, 1 ♀.

#### *Culicoides kanagai* Khamala & Kettle (Fig. 14)

*Culicoides kanagai* Khamala & Kettle 1971: 49 (female). Holotype: ♀, Nairobi, Kenya, C. Khamala, light trap, III-66. Paratype: 1 ♀, same data as holotype (BMNH).

**Diagnosis.** A small, dark brown species. Distal antennal segments not elongate; sensilla coeloconica on antennal segments 3, 11-15; 3rd segment of maxillary palpus moderately slender, with a small, moderately deep sensory pit; proboscis long. Legs without prominent pale bands. Wing infuscated grayish, with only 2 weak pale spots, over r-m crossvein and just distad of 2nd radial cell. Spermathecae subequal. Male unknown.

**Female.** Wing length 0.73-0.78 mm ( $n = 3$ ). **Head.** Dark brown. Eyes contiguous for a distance equal to the diameter of 1.5 ocular facets; with short interfacetal setae. Antenna with flagellar lengths in mean proportion of 17-12-12-12-12-12-14-20-19-20-19-27; A.R. 0.90-1.02 ( $n = 3$ ); sensilla coeloconica (with number per segment) on segments 3(4), 11(1), 12(1), 13(1), 14(1), 15(1). Third segment of maxillary palpus moderately slender, with a small, rounded, moderately deep sensory pit; P.R. 2.33-2.44 ( $n = 3$ ). Proboscis long, P/H 0.94-0.98 ( $n = 2$ ); mandible with 12-13 teeth ( $n = 2$ ).

**Thorax.** Dark brown. Legs brown; femora and tibiae pale basally; hindtibial comb with 5 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined mostly near apex, especially in cell R5. Membrane infuscated pale grayish, with only 2 small, weak pale spots, one over the r-m crossvein, the other on anterior margin just distad of 2nd radial cell; stigma darkened. Costal ratio 0.52-0.54 ( $n = 3$ ).

**Abdomen.** Dark brown. Spermathecae subequal, ovoid, without sclerotized necks; sclerotized ring

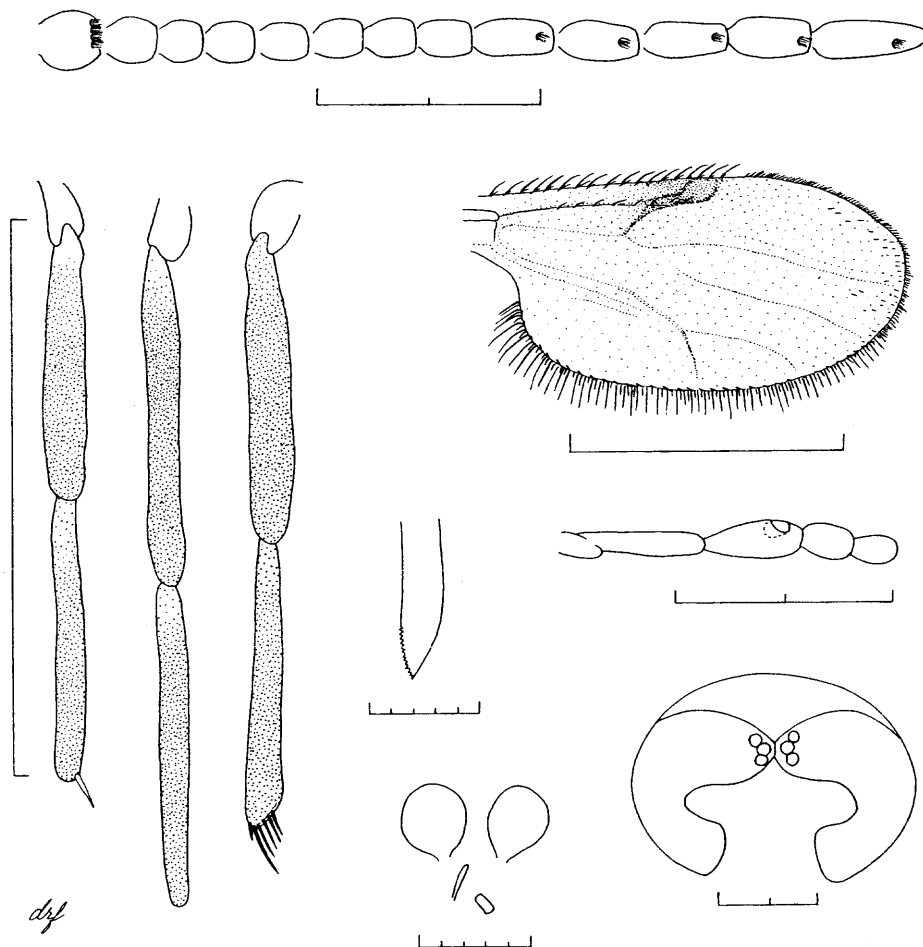


Fig. 14. *Culicoides kanagai* (*imicola* group). Adult female. (See key for scale.)

moderately long; functional spermathecae 0.060 by 0.025 and 0.060 by 0.029 mm.

**Male.** Unknown.

**Discussion.** Although the male is unknown, the placement of *kanagai* in the *imicola* group (Khamala & Kettle 1971) appears to be correct based on female characters.

The type specimens, as well as other material from Kenya and Zimbabwe, all had interfacetal setae (not mentioned in the original description of Khamala & Kettle [1971]). Also, all the material studied had five spines in the hindtibial comb as opposed to six as stated in the original description.

**Bionomics.** The immature stages and larval habitat of *C. kanagai* are undescribed.

Khamala (1971) collected two females from an *Acacia* savanna and grassland (high altitude) at Nairobi, Kenya. Braverman & Hulley (1979) predicted the host preference of *kanagai* to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Kenya, Zimbabwe.

**Material Examined.** KENYA: Nairobi, C. Khamala, light trap, III-66, ♀ paratype; no locality,

A. R. Walker, 1971–1974, 1 ♀. ZIMBABWE: University of Zimbabwe, R. J. Phelps, IV-74, 1 ♀.

***Culicoides kibatiensis* Goetghebuer**  
(Fig. 15)

*Culicoides kibatiensis* Goetghebuer 1935b: 172 (male). Holotype: ♂ no. 15 MK, N. Kivu, Kibati, Belgian Congo, Dr. De Wulf, XI-XII-33 (MRAC). Paratypes: ♂♂ no. 2, 4, 5, 9, 12 MK, same data as holotype; ♂♂ no. 3, 7, 8, 11, 16 MK, ♀ no. 13 MK, same data except lava plain, Dr. De Wulf, X-33 (MRAC, IMRJ).

*Culicoides volatilis* Goetghebuer 1935b: 176 (female). Holotype: ♀ no. 44 MK, N. Kivu, Kibati, Belgian Congo, lava plain, Dr. De Wulf X-33 (MRAC).

**Diagnosis.** A moderately large, brownish species. Female with 3rd segment of maxillary palpus moderately slender, with a shallow sensory pit; proboscis moderately long. Wing membrane grayish brown, veins brown; only 2 prominent pale spots, over r-m crossvein, and distad of 2nd radial cell,

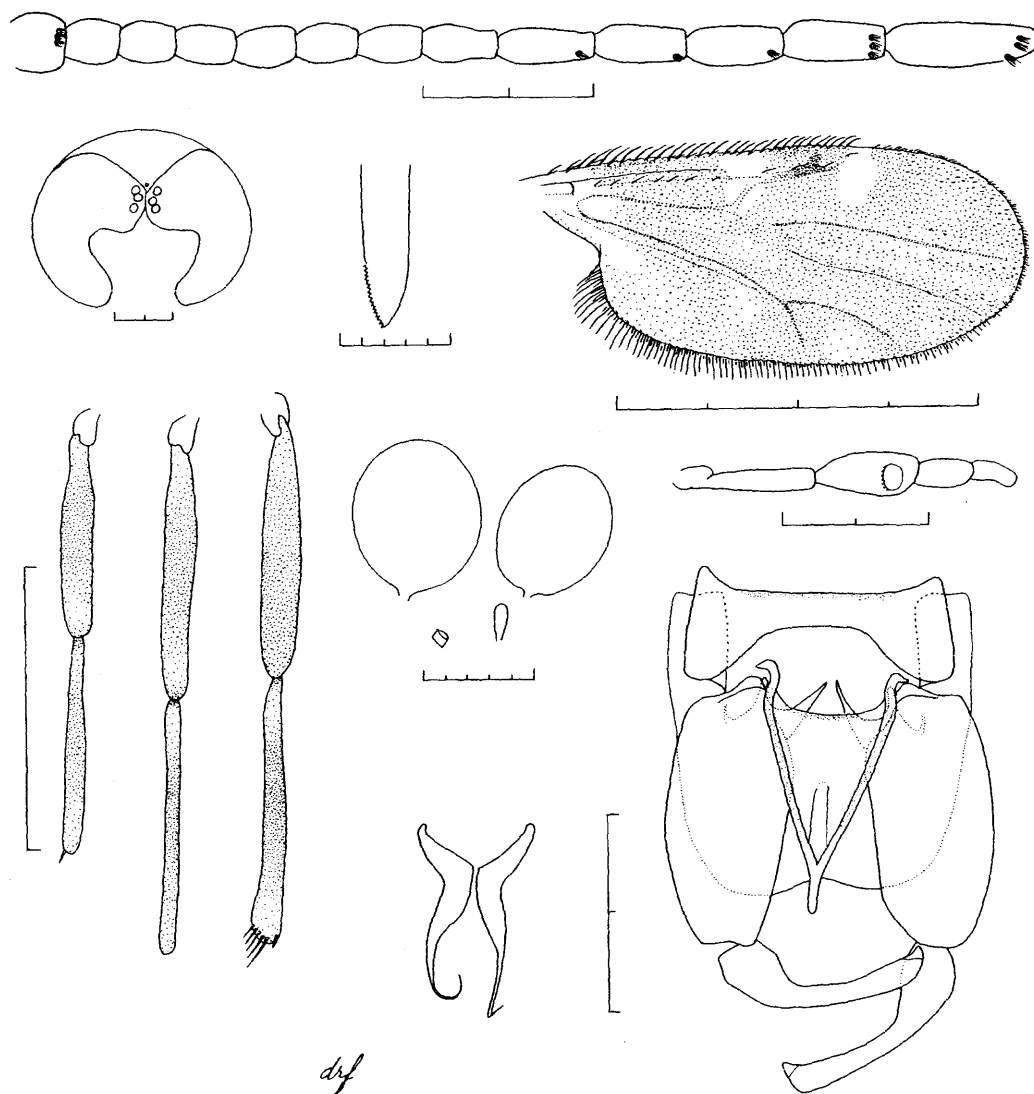


Fig. 15. *Culicoides kibatiensis* (*imicola* group). Adult female, male genitalia. (See key for scale.)

other pale markings indistinct; macrotrichia numerous over distal  $\frac{1}{4}$  of wing. **Male Genitalia.** Ninth tergum without apicolateral processes; aedeagus with a slender distal median process, apex rounded, and with a long, subapical, anteriorly directed ventral process; parameres bare at apices.

**Female.** Wing length 1.24–1.54 mm ( $n = 2$ ). **Head.** Brown. Eyes contiguous for a distance equal to diameter of about 1.5 ocular facets; without interfacetal setae. Antenna with flagellar lengths in proportion of 22–17–17–18–19–19–24–31–30–31–35–47; A.R. 1.05–1.12 ( $n = 2$ ); sensilla coelconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(3), 15(3). Third segment of maxillary palpus moderately slender, with a shallow sensory pit; P/R. 2.42–2.46 ( $n = 2$ ). Proboscis moderately long, P/H 0.87–0.91 ( $n = 2$ ); mandible with 16–17 teeth ( $n = 2$ ).

**Thorax.** Brown. Legs brown; femora pale basally, fore- and midfemora each with a weak subapical pale band; tibiae each with a subbasal pale band, apex of hindtibia paler; hindtibial comb with 5 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia numerous over distal  $\frac{1}{4}$  of wing, especially near margin. Membrane grayish brown, veins infuscated brown. Wing with a large, prominent pale spot over r-m crossvein extending anteriorly to costal margin, and a large prominent pale spot in cell R5 on anterior margin just distad of 2nd radial cell, extending slightly over apex of cell; other pale spots on wing indistinct, distal  $\frac{1}{2}$  of cell R5 with a broad pale area; broad pale streaks in cells M1 and M2; pale areas in distal portion of cell M4, and in base and distal portion of anal cell. Costal ratio 0.60–0.61 ( $n = 2$ ).

**Abdomen.** Brown. Spermathecae unequal, ovoid,

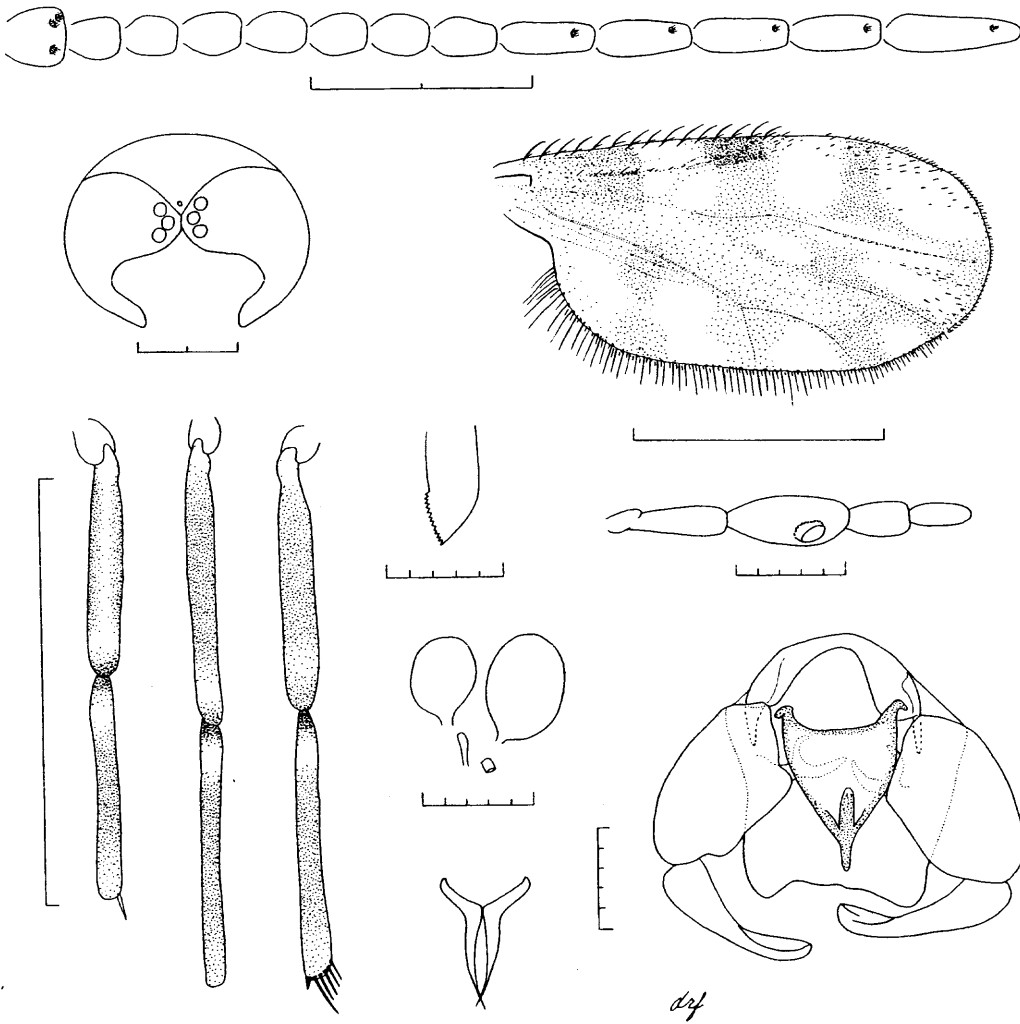


Fig. 16. *Culicoides pseudopallidipennis* (*imicola* group). Adult female, male genitalia. (See key for scale.)

with very short necks; sclerotized ring short; functional spermathecae 0.071–0.072 by 0.055–0.058 mm and 0.060 by 0.049 mm ( $n = 2$ ).

**Male Genitalia.** Ninth tergum with tapering sides; caudal margin broadly rounded, with a shallow mesal emargination. Ninth sternum with a broad, deep caudomedian emargination; ventral membrane not spiculate. Basistyle moderately long, stout; dorsal root short and stout, ventral root long, broad basally, directed anteromesally, tapering distally to a slender point; dististyle strongly curved just past base, distal portion straight and stout, curving at apex to a blunt point. Aedeagus elongate, V-shaped; lateral arms slender, bases curved laterally; lateral arms connected by a broad sclerotized membrane, basal arch shallow; distal median process slender, apically rounded; aedeagus with a long, subapical, anteriorly directed ventral process. Paramere stout, basal  $\frac{1}{3}$  directed anterolaterally; distal portion of stem tapering to a very slender, pointed apex, without setae.

**Discussion.** Khamala & Kettle (1971) described the male as having setae on the apices of the parameres; however, two male types from the BMNH did not have this character. *C. kibatiensis* is somewhat similar to *trifasciellus* Goetghebuer but does not have any of the subgroup characters as defined by Cornet (personal communication; see *trifasciellus*).

lected by Dipeolu (1976a) and Dipeolu & Ogunrinade (1976) in Nigeria probably belong to this species.

**Distribution.** Kenya, Nigeria, Tanzania, Uganda, Zaire.

**Material Examined.** KENYA: No locality, A. R. Walker, 1971–1976, 2 ♀♀. ZAIRE: (Belgian Congo), N. Kivu, Kibati, lava plain, Dr. De Wulf, X-33, 2 ♂ paratypes.

***Culicoides pseudopallidipennis* Clastrier**  
(Fig. 16)

*Culicoides pseudopallidipennis* Clastrier 1958: 197 (female). Types: 3 ♀♀, Niokolo-Koba National Park, Senegal, M. P. L. Dekeyser, UV light, III–IV–57; 1 ♀, Dakar, M. E. Abonnenc, light trap, X-57 (IPA).

**Diagnosis.** A moderately small, dark brown species. Female with 3rd segment of maxillary palpus moderately expanded, with a moderately deep sensory pit; proboscis long. Wing extensively pale, pattern similar to that of *imicola*, except cell M1 paler, the dark areas reduced to only 1 prominent area proximal to vein M2 at its midlength; distal portion of 2nd radial cell pale. **Male genitalia.** Ninth tergum with short and very broad, triangulate apicolateral processes; aedeagus with slender distal median process; apices of parameres bare.

**Female.** Wing length 0.86 mm (0.80–0.94 mm,  $n = 5$ ). **Head.** Dark brown, antenna and palpus paler. Eyes contiguous for a distance equal to the diameter of about 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 15–11–11–12–12–12–13–18–19–19–19–29; A.R. 1.06 (1.05–1.07,  $n = 4$ ); sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(1), 15(1). Third segment of maxillary palpus moderately expanded, with a small, rounded, moderately deep sensory pit; P.R. 2.38 (2.30–2.50,  $n = 4$ ). Proboscis long, P/H 0.94 (0.88–0.98,  $n = 5$ ); mandible with 15 teeth (13–16,  $n = 4$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, forefemur pale subapically and through middle to base, midfemur with a subapical pale band, hindfemur vaguely paler subapically; tibiae each with a subbasal pale band, and paler apically; hindtibial comb with 5 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse at apex, most abundant in distal portion of cell R5. Wing pattern very similar to that of *C. imicola*, except cell M1 paler, the dark areas bordering vein M2 reduced, with only 1 distinct gray area at midlength. Costal ratio 0.54 (0.53–0.56,  $n = 5$ ).

**Abdomen.** Brown. Spermathecae unequal, ovoid, with short necks; rudimentary 3rd short and narrow; sclerotized ring moderately short; functional spermathecae 0.052–0.053 by 0.039–0.046 mm ( $n = 2$ ) and 0.041–0.044 by 0.035–0.038 mm ( $n = 2$ ).

**Male Genitalia.** Ninth tergum with slightly tapering sides and short and very broad, triangulate apicolateral processes. Ninth sternum with a very broad and deep caudomedian emargination, ventral membrane not spiculate. Basistyle with long, apically pointed dorsal and ventral roots; dististyle moderately curved distally, with bluntly pointed apex. Aedeagus with a shallow basal arch, lateral arms with short, laterally directed bases; sides of aedeagus tapering to a short, slender distal median process with rounded apex; aedeagus with a moderately long, anteriorly directed subapical process, arising from just above base of distal median process. Paramere with basal  $\frac{1}{2}$  directed anterolaterally; distal portion nearly straight, posteriorly directed, tapering to a very slender, sharply pointed apex, without setae.

**Discussion.** *Culicoides pseudopallidipennis* is similar to *imicola*, with which it probably has often been confused in the past. It can best be recognized by the paler cell M1 (dark areas reduced to only one prominent area proximal to vein M2), and by its antennal sensory pattern of 3, 11–15 rather than 3, 12–15.

Clastrier (1958) did not illustrate the wing or describe the antennal sensory pattern for *pseudopallidipennis* when he described the female; he noted the reduction of gray bands on the wing (cell M1) and the paler legs.

**Bionomics.** The immature stages and larval habitat of *pseudopallidipennis* are undescribed. Cornet (1969) noted that this species is apparently rare in Senegal. Feeding habits of the adults have not been recorded.

**Distribution.** Kenya, Senegal, Zimbabwe.

**Material Examined.** KENYA: Ol Doiyo Sabachi, A. R. Walker, 11–XII–71, 1 ♀, 1 ♂; Rift Valley Province, Marigat, D. Young and R. Beach, light trap, 7–10–VII–81, 3 ♀♀. ZIMBABWE: Inyanga North, C. Green, 13–II–70, 1 ♀.

***Culicoides spinifer* Khamala & Kettle**  
(Fig. 53, left)

*Culicoides spinifer* Khamala & Kettle 1971: 51 (male). Holotype: ♂, Kaimosi, Kenya, C. Khamala, light trap, 10–X–66 (BMNH).

**Diagnosis.** A medium-sized, dark brown species. Wing extensively pale, pattern somewhat similar to that of *C. grahamii*, with large pale spots over r-m crossvein, just distad of 2nd radial cell, and at apex of cell R5; broad pale streaks filling most of cells M1 and M2; cell M4 and anal cell mostly pale. **Male Genitalia.** Ninth tergum with short, stout, triangulate apicolateral processes; aedeagus V-shaped, distal median process short and slender with rounded apex; aedeagus with a very long, slender, apically pointed ventral process, arising from above and between junction of lateral arms, and extending posteriorly beyond caudal margin of 9th tergum; apices of parameres bare.

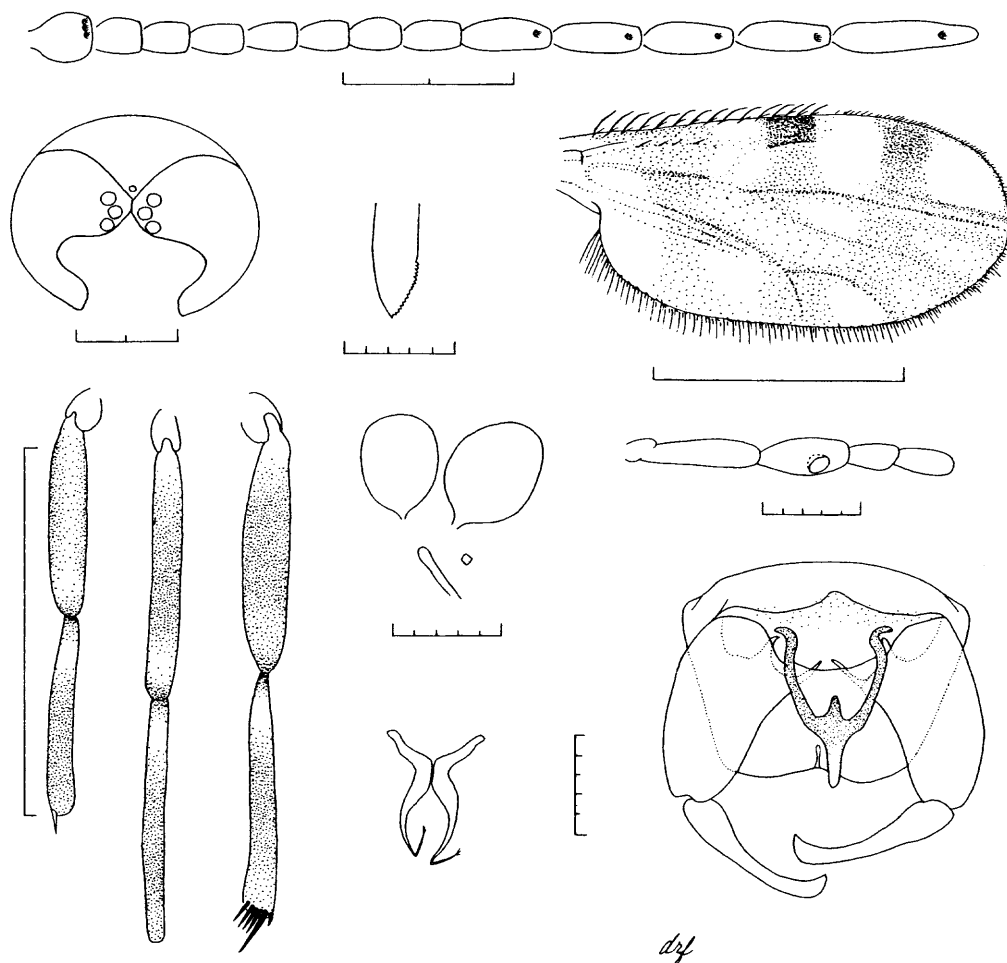


Fig. 17. *Culicoides trifasciellus* (*imicola* group). Adult female, male genitalia. (See key for scale.)

**Male** (described from holotype). Wing length 0.94 mm. Head, thorax, and abdomen dark brown. Mesonotum without pattern. Legs pale brown; femora pale basally, fore- and midfemora broadly pale subapically; fore- and midtibiae each with a subbasal pale band, midtibia paler apically, hindtibia entirely pale except at extreme apex; hindtibial comb with 5 spines, that nearest the spur very stout and elongate relative to the other 4 spines. Halter pale.

**Wing.** Macrotrichia absent except for several in distal portion of cell R5 near margin. Pattern of pale spots typical of the *imicola* group, somewhat similar to *grahamii*; large pale spot over r-m crossvein, extending anteriorly to costal margin, and posteriorly into cell M2; cell R5 with a large pale spot on anterior margin just distad of 2nd radial cell and extending over apex, and a moderately large pale spot at apex of cell; cell M1 with a broad pale streak extending from base to apex, almost entirely filling cell; cell M2 almost entirely pale in proximal  $\frac{1}{2}$ , coalescing with pale spot over r-m crossvein, distal  $\frac{1}{2}$  with a broad pale streak almost entirely filling cell; cell M4 with a large pale spot

filling most of cell; anal cell extensively pale in proximal  $\frac{1}{2}$ , coalescing with a large pale spot in distal portion of cell; wing veins infuscated brownish, particularly radial veins and proximal  $\frac{1}{2}$  of vein M1.

**Male Genitalia.** Ninth tergum with tapering sides and short, stout, triangulate apicolateral processes; caudal margin with a narrow mesal cleft. Ninth sternum with a broad, deep caudomedian emargination; ventral membrane not spiculate. Basistyle broad, dorsal and ventral roots long and moderately stout, dorsal roots hooked mesally at apices; dististyle moderately stout, slightly curved, apex bluntly pointed. Aedeagus V-shaped, arms laterally directed at bases, connected by a broad, sclerotized membrane forming a moderately deep basal arch; distal median process short and slender, apically rounded; aedeagus with a very long, slender, apically pointed ventral process, arising from just above and between junction of lateral arms and extending posteriorly well beyond caudal margin of 9th tergum. Paramere stout, base directed anterolaterally; main stem gradually tapering distally to a filamentous, pointed apex, without setae.



**Female.** Unknown.

**Discussion.** *Culicoides spinifer* is known only from the male holotype. The virtual absence of macrotrichia at the wing apex and very stout and elongate first spine of the hindtibial comb place *spinifer* close to Cornet's *trifasciellus* subgroup. The long, slender ventral process of the aedeagus distinguishes *spinifer* from all other members of the *imicola* group.

**Bionomics.** The immature stages and larval habitat are unknown. The male holotype was collected by light trap in October.

**Distribution.** Kenya.

**Material Examined.** KENYA: Kaimosi, C. Khamala, light trap, 10-X-66, ♀ holotype.

***Culicoides trifasciellus* Goetghebuer**  
(Fig. 17)

*Culicoides trifasciellus* Goetghebuer 1935b: 175 (female). Holotype: ♀ no. 46 MK, Rutshuru, Belgian Congo, Dr. De Wulf, I-34 (MRAC).

*Culicoides glabripennis* Goetghebuer 1935b: 171 (misident., in part). Type: ♀ no. 22 MK (as *nudipennis* Goetghebuer), Kisantu, Belgian Congo, Dr. De Wulf, 1931 (MRAC).

*Culicoides kibatiensis* Goetghebuer 1935b: 172 (misident., in part). Paratype: ♂ no. 6 MK, Rutshuru, Belgian Congo, Dr. De Wulf, I-34 (MRAC).

*Culicoides rutshuruensis* Goetghebuer 1935b: 174 (misident., in part). Paratype: ♀ no. 55 MK, Rutshuru, Belgian Congo, Dr. De Wulf, I-34 (MRAC).

*Culicoides irroratus* Goetghebuer 1948: 12 (misident., in part). Paratypes: ♂♂ no. 29, 30 MK, ♀ no. 100 MK, Kivu, Rutshuru, Belgian Congo, 1,285 m elev., G. F. de Witte, 23-25-XII-33; ♀ no. 34 MK, Kivu, Rutshuru, Belgian Congo, 1,285 m elev., G. F. de Witte, 11-VII-35 (MRAC).

**Diagnosis.** A moderately small, dark brown species. Female 3rd segment of maxillary palpus with a small, shallow sensory pit. Hindtibial comb with 1st spine very long and stout relative to the other 4 spines. Wing extensively pale, with very large pale spots over r-m crossvein, on anterior margin extending over distal portion of 2nd radial cell, and at apex of cell R5; broad pale streaks filling most of cells M1 and M2; macrotrichia absent except for a few at apex. **Male Genitalia.** Ninth tergum without apicolateral processes; ventral membrane of 9th sternum spiculate; aedeagus with a short, anteriorly directed subapical process; apices of parameres setose.

**Female.** Wing length 0.87 mm. **Head.** Dark brown, antenna and palpus paler. Eyes contiguous for a distance equal to the diameter of about 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 17-11-12-13-13-13-15-23-23-24-25-37; A.R. 1.23; sensilla coeloconica (with number per segment) on

segments 3(3), 11(1), 12(1), 13(1), 14(1), 15(1). Third segment of maxillary palpus moderately swollen, with a small, rounded, shallow sensory pit; P.R. 2.29. Proboscis moderately short, P/H 0.77; mandible with 16 teeth.

**Thorax.** Dark brown. Legs brown; femora pale basally, forefemur pale subapically and through middle to base, midfemur with a subapical pale band; tibiae each with a subbasal pale band, apices paler; hindtibial comb with 5 spines, the 1st much longer and stouter than the other 4 spines. Halter pale.

**Wing.** Macrotrichia absent except for a few at apex. Wing extensively pale, with very large pale spots over r-m crossvein, on anterior margin of cell R5 extending over distal portion of 2nd radial cell, and at apex of cell R5; cell M1 with a long, broad pale spot in basal ½, and a long broad pale streak in distal ½; cell M2 with a long, broad pale area at middle coalescing with a large pale spot at apex; cell M4 with a large pale spot in distal portion proximal to vein M3+4; anal cell with a very large, irregular pale area distally; wing base broadly pale, extending caudally into basal ¼ of anal cell; vein M1 with a broad pale streak over distal ½. Costal ratio 0.60.

**Abdomen.** Brown. Spermathecae unequal, ovoid, with short necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.058 by 0.043 and 0.048 by 0.040 mm.

**Male Genitalia.** Ninth tergum with tapering sides, apicolateral processes absent; caudal margin with a shallow caudomedian emargination. Ninth sternum with a short, narrow caudomedian emargination; ventral membrane spiculate. Basistyle with long, apically pointed dorsal and ventral roots, dorsal root moderately stout, ventral root slender; dististyle nearly straight, distally slender, broader near apex and curving to a pointed tip. Aedeagus with a moderately shallow basal arch, membrane between lateral arms not appearing heavily sclerotized, bases curved laterally; sides of aedeagus tapering to a long, moderately stout distal median process, apex rounded; aedeagus with a short, stout, anteriorly directed subapical process, arising from just above base of distal median process. Paramere with basal ¼ bent anterolaterally, stem tapering, distally recurved to a slender, pointed, setose apex.

**Discussion.** Cornet's subgroup *trifasciellus* of the *imicola* group is characterized by the absence (or extreme rarity) of wing macrotrichia, the first spine of the hindtibial comb is greatly broadened and much longer than the other four, and the apices of the male parameres are setose (Cornet, personal communication).

Khamala & Kettle's (1971) description of *trifasciellus* males appears to be correct, except that the parameres are not illustrated or described as being setose at the apices.

**Bionomics.** The immature stages of *trifasciellus* are undescribed.

In Kenya (Khamala 1975; Lubega & Khamala

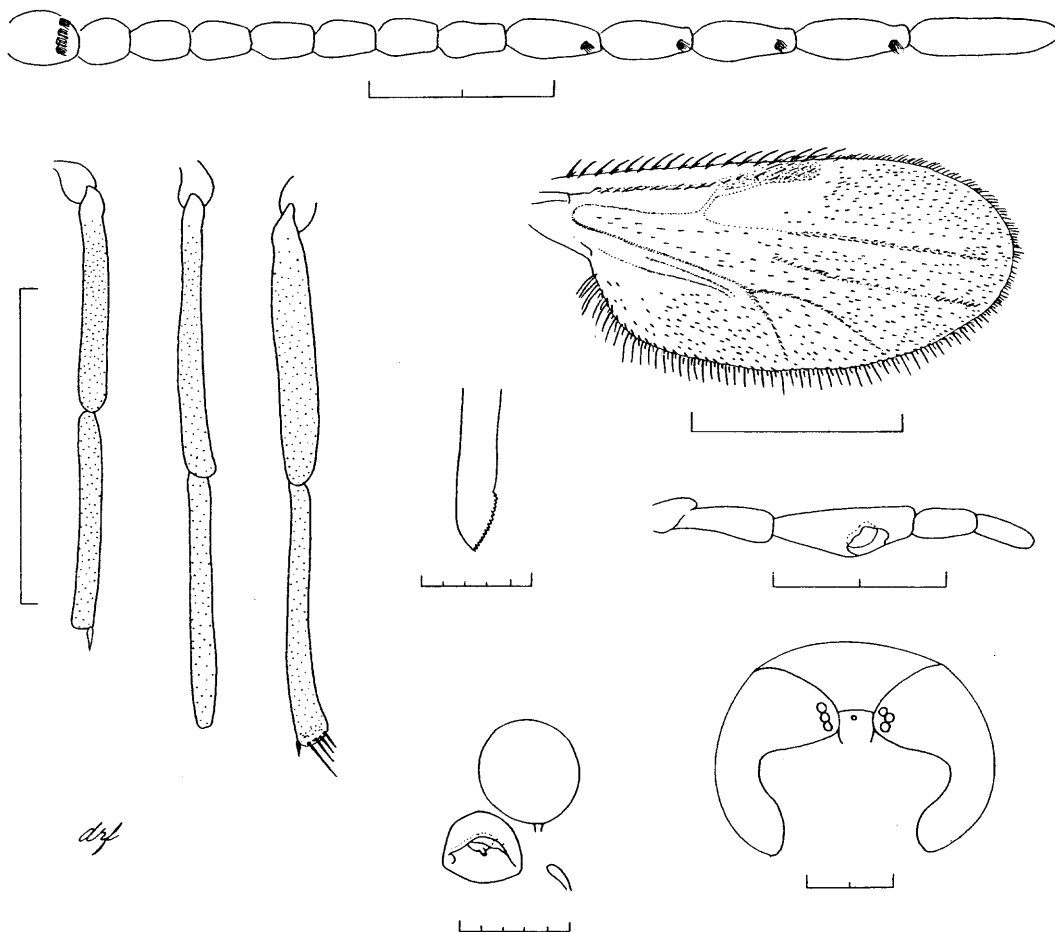


Fig. 18. *Culicoides nairobiensis*, n. sp. (*inornatipennis* group). Adult female. (See key for scale.)

1976), *trifasciellus* was reared in high numbers from water-logged mud with decaying vegetation in a *Cyperus* marsh at Lake Nakuru National Park; several adults also were obtained from water-logged mud from a *Typha* swamp.

Khamala (1971) collected a number of adults by light trap in East Africa from a high-altitude forest zone (Tanzania) and a large number of adults in a savanna zone (Kenya). Walker (1976) collected adults in Kenya from high-altitude forest and grassland, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

Khamala (1975) reported *trifasciellus* to be the major human-biting species at Lake Nakuru National Park, Kenya. Females caused severe annoyance, attempting to bite the exposed surfaces of the head, face, and hands. Biting intensity was almost equal during April, May, and June. Adults were primarily diurnal with peaks in the early morning hours and in the late evening. Biting began at 0730 hours, reaching a peak between 0800 and 0845 hours; intensity declined suddenly with almost no biting after 1030 hours (on bright, sunny

days). Biting activity resumed in the evening between 1730 and 1745 hours, reaching a peak at about 1800 hours. No biting was recorded after 2030 hours. Morning peak numbers were always much greater than those of the evening peak, and biting populations were greater in an open, unsheltered field than in a wooded, sheltered area near its breeding site.

Braverman & Hulley (1979) predicted the host preference of *trifasciellus* to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Kenya, Senegal, Tanzania, Zaire.

**Material Examined.** KENYA: Nairobi Province, Nairobi, Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 19-V-82, 1 ♂. SENEGAL: 3 km N of Kedougou, Galerie Forest, 25-VII-72, 1 ♀; same data, 29-VII-72, 1 ♂.

#### *Culicoides inornatipennis* Group

**Diagnosis.** Female eye separation variable, often broad. Female antennal sensory pattern variable, often 3, 11-15. Wing without pale spots. Female abdomen with 2 functional spermathecae and a

rudimentary 3rd, sclerotized ring usually present at junction of ducts. **Male Genitalia.** Ninth tergum with well-developed apicolateral processes; basistyle with dorsal and ventral roots long and slender; distal median process of aedeagus usually moderately stout with blunt apex; parameres separate, stem tapering distally to a simple, pointed apex.

**Kenya Species.** *C. nairobiensis* Glick, n. sp.

***Culicoides nairobiensis* Glick, new species**  
(Fig. 18)

**Diagnosis.** A medium-sized, brownish species. Female eyes widely separated; distal antennal segments elongate; sensilla coeloconica on antennal segments 3, 11–14; 3rd segment of maxillary palpus slender, with a moderately shallow sensory pit; proboscis long. Legs without pale bands. Wing without pale spots; macrotrichia dense. Female abdomen with spermathecae unequal; sclerotized ring absent. Male unknown.

**Female.** Wing length 1.06 mm. **Head.** Brown. Eyes widely separated by a distance equal to the diameter of 3 ocular facets; without interfacetal setae. Antenna with flagellar lengths in proportion of 19–18–13–14–15–15–15–16–22–21–23–27–36; A.R. 1.08; sensilla coeloconica (with number per segment) on segments 3(4), 11(1), 12(1), 13(1), 14(1). Third segment of maxillary palpus slender with a moderate distal swelling, sensory pit moderately large and shallow; P.R. 2.88. Proboscis long, P/H 1.00; mandible with 15–17 teeth.

**Thorax.** Brown; mesonotum dark brown, scutellum yellowish brown. Legs pale grayish brown; femora pale basally; hindtibial comb with 4 spines, that nearest the spur longest. Halter very pale grayish.

**Wing.** Membrane infuscated very pale grayish brown, veins slightly darker; without pattern of pale spots. Macrotrichia dense over most of wing, absent from costal and basal cells, and in cell R5 proximal to radial cells. Costal ratio 0.56.

**Abdomen.** Brown. Spermathecae dark brown, unequal, ovoid, with very short, sclerotized necks; rudimentary 3rd short and narrow; sclerotized ring absent; larger functional spermatheca 0.048 by 0.044 mm; smaller spermatheca collapsed, width 0.037 mm.

**Male.** Unknown.

**Etymology.** The specific name is derived from the type locality.

**Discussion.** *Culicoides nairobiensis* n. sp. can be distinguished from other members of the *inornatipennis* group in East Africa by the widely separated eyes, the antennal sensory pattern of 3, 11–14, the morphology of the third palpal segment, and the long proboscis.

**Bionomics.** The immature stages and larval habitat of *nairobiensis* are undescribed. The single known female was collected by light trap with CO<sub>2</sub> in Kenya in a lower stream forest near the Mbagathi River in early December. *C. nairobiensis*

may have a feeding preference for larger mammals based on its low number of antennal sensilla.

**Distribution.** Kenya; known only from the type locality.

**Type Material.** HOLOTYPE: ♀, Nairobi Province, Kenya, Nairobi, Karen, 800 m W Karen Rd., 1,000 m S Bongani Rd., N fork of Mbagathi River, Noad Farm, lower stream forest, 1,650 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 5-XII-81 (USNM Type No. 100686).

***Culicoides milnei* Group**

**Diagnosis.** Female eyes usually contiguous. Female antenna with sensilla coeloconica usually on segments 3, 11–15. Third segment of maxillary palpus with sensilla distributed in more than 1 sensory pit. Hindtibial comb with 5 or 6 spines. Wing with prominent pattern of distinct pale spots; distal portion of 2nd radial cell pale. Female abdomen with 2 functional spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum rounded caudally, apicolateral processes very short or absent; basistyle with dorsal root short, ventral root usually absent; aedeagus with low basal arch, anterior margin often heavily sclerotized, distal median process slender with rounded apex; aedeagus often with anteriorly directed subapical process arising from just above distal median process; parameres usually separate, basal portion of stem directed anterolaterally, stem distally tapering to a slender, pointed, setose apex.

**Kenya Species.** *C. giganteus* Khamala & Kettle, *C. isiolensis* Cornet, Nevill & Walker, *C. kerichoensis* Khamala & Kettle, *C. krameri* Clastrier, *C. milnei* Austen, *C. moreli* Clastrier, *C. zuluensis* De Meillon.

***Culicoides giganteus* Khamala & Kettle**  
(Fig. 19)

*Culicoides giganteus* Khamala & Kettle 1971: 35 (male, female). Holotype: ♀, Mt. Kenya, Kazito Valley West, Kenya, above forest line in afro-alpine heath and moorland zone, 13,000 ft elev., R. Harmsen, light trap, VI-66 (BMNH). Paratypes: 1 ♂, 5 ♀♀, same data as holotype (1 ♂, BMNH; 2 ♀♀, USNM; 1 ♀, MRAC; 2 ♀♀, NMK).

**Diagnosis.** A very large, dark brown species. Female 3rd segment of maxillary palpus with 1 large and 1 small sensory pit. Legs without pale bands. Wing with a moderately distinct pattern similar to other members of the group, especially *kerichoensis*; apex of wing dark. **Male Genitalia.** Ninth tergum with short, converging apicolateral processes; inner margin of basistyle with a long row of stout spines.

**Female.** Wing length 2.21–2.33 mm ( $n = 2$ ). **Head.** Dark brown. Eyes contiguous for a distance equal to the diameter of about 2 ocular facets; without interfacetal setae. Antenna with flagellar

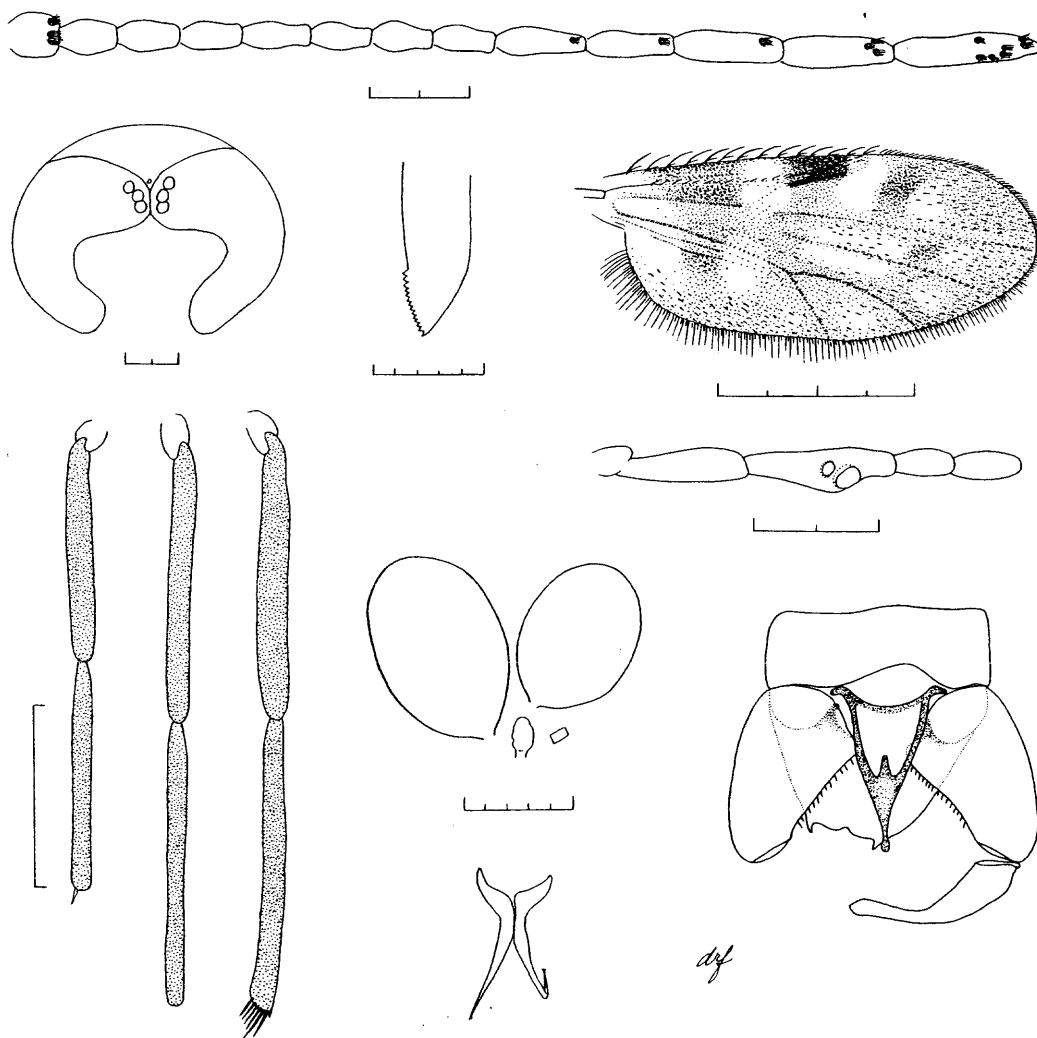


Fig. 19. *Culicoides giganteus* (*milnei* group). Adult female, male genitalia. (See key for scale.)

lengths in proportion of 28–26–28–28–30–28–27–27–40–38–44–49–68; A.R. 1.08–1.14 ( $n = 2$ ); sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(3), 15(4–7). Third segment of maxillary palpus long and slender with a swelling just past middle, and with 1 large and 1 small, shallow sensory pit; P.R. 3.24–3.52 ( $n = 2$ ). Proboscis moderately long, P/H 0.81–0.88 ( $n = 2$ ); mandible with 14–17 teeth ( $n = 2$ ).

**Thorax.** Very dark brown. Legs dark brown; tibiae weakly paler at bases, hindtibia weakly paler at apex; hindtibial comb with 6 spines, the 2nd from the spur longest. Halter stem infuscated brownish, knob pale.

**Wing.** Macrotrichia abundant over distal  $\frac{1}{2}$  of wing and in anal cell near posterior wing margin. Wing pattern similar to that of *C. kerichoensis*, pale spots over posterior portions of wing less distinct; large pale spots over r-m crossvein, in cell R5 on anterior margin covering distal portion of 2nd

radial cell, and in distal portion of cell R5; base of cell M1 and middle of cell M2 with broad, elongate pale spots coalescing over vein M2, forming a large, rectangular spot; cells M1, M2 and M4 each with a pale spot in distal portion; wing base broadly pale, extending into anal cell to posterior wing margin; anal cell with a large pale spot at mid-length, proximal to cubital vein and extending into cell M2, and with a smaller pale spot at apex of cell; apex of wing dark; wing veins infuscated brown. Costal ratio 0.60–0.62 ( $n = 2$ ).

**Abdomen.** Dark brown. Spermathecae very dark brown, large, unequal, ovoid, without sclerotized necks; rudimentary 3rd short, ovoid; sclerotized ring short and wide; functional spermathecae 0.087–0.092 by 0.060–0.061 mm and 0.074–0.077 by 0.052–0.055 mm ( $n = 2$ ).

**Male Genitalia** (based on Khamala & Kettle's [1971] description and illustration). Ninth tergum with tapering sides (untapered in Khamala & Ket-

tle 1971), and with short, pointed, converging apicolateral processes; caudal margin with a short mesal emargination. Ninth sternum with a broad, moderately shallow caudomedian emargination; ventral membrane not spiculate. Basistyle broadest basally, inner margin with a long row of short, stout spines; dorsal root moderately long, stout, ventral root absent; dististyle broad over basal  $\frac{1}{2}$ , bent just past middle, distally straight and more slender, with bluntly pointed apex. Aedeagus with a shallow basal arch, anterior margin heavily sclerotized; lateral arms slender, directed laterally at bases; sides of aedeagus tapering to a long, slender distal median process with expanded, rounded apex; aedeagus with a short, anteriorly directed, subapical process arising from just above base of distal median process. Parameres separate; basal  $\frac{1}{3}$  directed anterolaterally; distal portion of stem tapering to a slender, pointed, setose apex.

**Discussion.** *Culicoides giganteus* can be distinguished readily from other members of the *milnei* group in Kenya by its large size and legs without pale bands. The male genitalia are similar to these of other members of the group. This species is known only from the type locality (Kazito Valley, Mt. Kenya).

**Bionomics.** The immature stages and larval habitat of *giganteus* are undescribed. *Culicoides giganteus* was the only species of *Culicoides* found in the afro-alpine zone in Kenya (Khamala 1971). The feeding habits of *giganteus* are unknown. Braverman & Hulley (1979) predicted its host preference to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Kenya.

**Material Examined.** KENYA: Mt. Kenya, Kazito Valley West, above forest line in afro-alpine heath and moorland zone, R. Harmsen, light trap, VI-66, 2 ♀ paratypes.

***Culicoides isiolensis***  
**Cornet, Nevill & Walker**  
(Fig. 20)

*Culicoides isiolensis* Cornet, Nevill & Walker 1974: 240 (female). Holotype: ♀ no. 2475, Isiolo, Kenya, A. R. Walker, 11-XII-71. Paratypes: ♀ no. 2474, same data as holotype (ORSB); ♀♀ no. 2476, 2477, same data as holotype (BMNH).

**Diagnosis.** A moderately large, dark brown species. Female 3rd segment of maxillary palpus slender, with a moderately large, shallow, irregularly ovoid sensory pit, and 1-2 smaller, shallow pits. Wing with pale markings large and distinct; wing base extensively pale; apex of wing pale. Male unknown.

**Female.** Wing length 1.25-1.36 mm ( $n = 2$ ). **Head.** Dark brown; antennal segments 3-10 pale basally. Eyes contiguous for a distance equal to the diameter of about 1.5 ocular facets; without inter-

facetal setae. Antenna with flagellar lengths in proportion of 20-17-17-18-19-18-20-20-29-29-31-35-50; A.R. 1.17-1.20 ( $n = 2$ ); sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(2), 15(2). Third segment of maxillary palpus long and slender with only a moderate swelling at midlength, and with a moderately large, shallow, irregularly ovoid sensory pit, and 1-2 smaller, shallow pits; P.R. 3.50-3.64 ( $n = 2$ ). Proboscis long, P/H 0.88-1.01 ( $n = 2$ ); mandible with 17 teeth.

**Thorax.** Dark brown. Legs dark brown; fore- and midfemora pale at apex; fore- and midtibiae each with a broad basal pale band, hindtibia with broad basal and apical pale bands; hindtibial comb with 5 spines, the 2nd from the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined mostly to distal  $\frac{1}{3}$  of wing. Wing with pale spots large and distinct; wing base extensively pale, with a very broad pale band extending from costal margin to posterior wing margin, filling basal  $\frac{1}{3}$  of anal cell; pale spot over r-m crossvein large and quadrangular, with a short caudal elongation into cell M2; cell R5 with a large, irregular pale spot on anterior margin, extending over apex of 2nd radial cell, and a transverse pale spot in distal  $\frac{1}{2}$  of cell; cell M1 with a pale spot at middle and another in distal portion; cell M2 with several irregular, coalescing pale areas in basal  $\frac{1}{2}$ , and 2 pale spots in distal  $\frac{1}{2}$ ; cell M4 with a large distal pale spot extending to wing margin; anal cell with a pale spot just below apex of anal vein, and another near apex of cell at wing margin; apex of wing with a distinct, narrow pale band extending to just above vein M2; wing membrane infuscated grayish brown, veins darker. Costal ratio 0.63-0.66 ( $n = 2$ ).

**Abdomen.** Dark brown. Spermathecae dark brown, slightly unequal, ovoid, with short, tapering necks; rudimentary 3rd short and narrow; sclerotized ring short; functional spermathecae 0.051 by 0.035 and 0.049 by 0.033 mm.

**Male.** Unknown.

**Discussion.** The combination of a prominent pale band at the wing apex and the third palpal segment with a single, large sensory pit (occasionally with one or two smaller ones) will help to distinguish *isiolensis* females from those of other *milnei* group species in Kenya. Cornet et al. (1974) noted that the palpal sensory organ of *isiolensis* is atypical for the *milnei* group, in which the sensilla are usually scattered singly or with two or more sensilla each in multiple, shallow pits.

**Bionomics.** The immature stages and larval habitat of *isiolensis* are undescribed. Walker (1976) collected adults in Kenya from arid *Acacia-Commiphora* bushland. The feeding habits of *isiolensis* are unknown, although Braverman & Hulley (1979) predicted its host preference to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Ethiopia, Kenya.

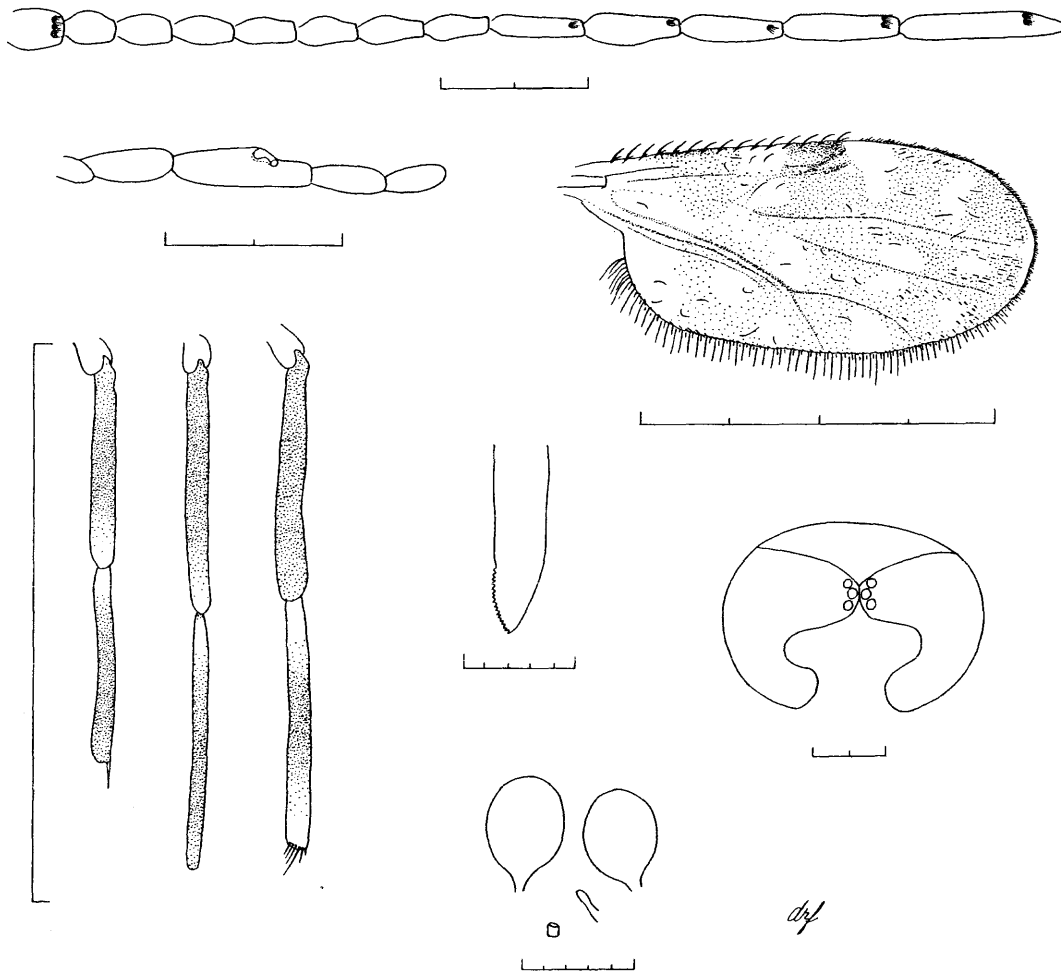


Fig. 20. *Culicoides isiloensis* (milnei group). Adult female. (See key for scale.)

**Material Examined.** ETHIOPIA: Kaffa Province, Buba Catholic Mission, about 4 km NE Wush-Wush, V. H. Lee, light trap and CO<sub>2</sub>, 21-22-V-74, 1 ♀; Chebara, Kulo Konta, hot springs, V. H. Lee, light trap and CO<sub>2</sub>, 20-21-X-74, 1 ♀.

***Culicoides kerichoensis* Khamala & Kettle**  
(Fig. 21)

*Culicoides kerichoensis* Khamala & Kettle 1971: 37 (female). Holotype: ♀, Kericho, Kenya, C. Khamala, light trap, 28-XI-66 (BMNH). Paratypes: 2 ♀♀, same data as holotype (1 ♀, USNM; 1 ♀, MRAC).

**Diagnosis.** A large, dark brown species; mesonotum yellowish. Female 3rd segment of maxillary palpus long and slender, with numerous small, rounded sensory pits. Wing pattern of very large and distinct pale spots; pale spot over r-m crossvein quadrangular, extending caudally well into cell M2; cell R5 with a pale spot covering most of the 2nd

radial cell and extending to vein M1; pale spots in basal portion of cell M1 and in middle of cell M2, coalescing into 1 very large rectangular pale spot over vein M2. **Male Genitalia.** Ninth tergum with short apicolateral processes; aedeagus with a short, stout, anteriorly directed subapical process.

**Female.** Wing length 1.49-1.54 mm ( $n = 3$ ). **Head.** Dark brown; antennal segments 3-10 pale basally. Eyes contiguous for a distance equal to the diameter of about 2 ocular facets; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 25-23-24-24-26-24-23-23-30-30-35-36-48; A.R. 0.91-0.93 ( $n = 3$ ); sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(2), 15(3). Third segment of maxillary palpus long and slender with only a slight swelling at midlength, and with numerous small, rounded, scattered sensory pits on distal ½; P.R. 4.10-4.22 ( $n = 3$ ). Proboscis moderately long, P/H 0.83-0.92 ( $n = 3$ ); mandible with 14-17 teeth ( $n = 3$ ).

**Thorax.** Dark brown; mesonotum yellowish. Legs

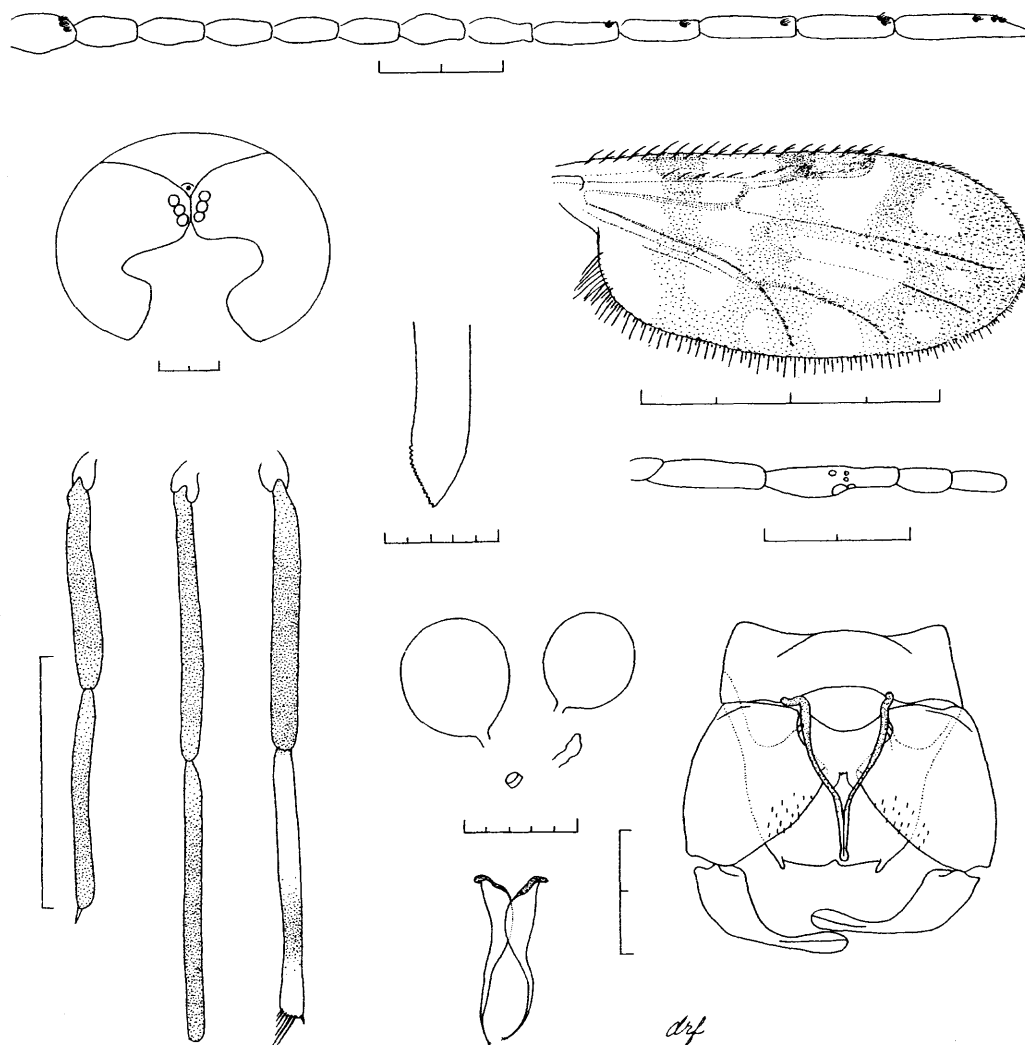


Fig. 21. *Culicoides kerichoensis* (*milnei* group). Adult female, male genitalia. (See key for scale.)

brown; fore- and midfemora pale apically; fore- and midtibiae pale basally, hindtibia pale over basal  $\frac{1}{2}$  and at apex; hindtibial comb with 6 spines, the 2nd from the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined to distal  $\frac{1}{4}$  of wing. Wing with prominent pattern of very large and distinct pale spots; wing base with a broad pale band extending from costal margin to posterior border; pale spot over r-m crossvein quadrangular, extending from costal margin well into cell M2; cell R5 with a pale spot on anterior margin extending over most of 2nd radial cell, and extending caudally to vein M1, and a pale spot just past middle of cell; pale spots in basal portion of cell M1 and in middle of cell M2, broadly coalescing into 1 very large rectangular pale spot over vein M2; cells M1 and M2 each with a small pale spot in distal portion; cell M4 with a pale spot filling distal  $\frac{3}{4}$  of cell, extending from vein M3+4 to posterior wing margin; anal cell with a pale spot

at middle, proximal to cubital vein and extending slightly into cell M2, and a small pale spot near apex; wing membrane infuscated grayish brown, darker in cell R5 between the 2 distal pale spots; veins brownish. Costal ratio 0.62–0.65 ( $n = 3$ ).

**Abdomen.** Dark brown. Spermathecae dark brown, unequal, ovoid, with short sclerotized necks; rudimentary 3rd narrow; sclerotized ring very short; functional spermathecae 0.058–0.062 by 0.046–0.048 mm ( $n = 3$ ) and 0.044–0.048 by 0.037–0.039 mm ( $n = 3$ ).

**Male Genitalia.** Ninth tergum with tapering sides and short, slender apicolateral processes; caudal margin with a short mesal emargination. Ninth sternum with a shallow caudomedian emargination; ventral membrane not spiculate. Basistyles short and very broad, dorsal root short and slender, ventral root very short; dististyle broad over basal  $\frac{1}{2}$ , abruptly bent at middle, distal  $\frac{1}{2}$  nearly straight, expanding to a rounded apex. Aedeagus with a

moderately shallow basal arch, lateral arms directed laterally at bases; sides gradually tapering distally to a long, slender distal median process, apex rounded; aedeagus with a short, stout, anteriorly directed subapical process with truncate apex. Parameres separate, nearly straight, stout basally, stem tapering distally to a slender, pointed apex with minute setae.

**Discussion.** Cornet et al. (1974) described and illustrated the male of *kerichoensis* from South Africa.

*Culicoides kerichoensis* can be separated easily from the other members of the *milnei* group by the extensive pale markings on the wing. The short apicolateral processes of the male ninth tergum are distinctive in the group (the only other Kenya species with short processes is *giganteus* Khamala & Kettle) and resemble the genitalia of the subgenus *Culicoides* s. str.

**Bionomics.** The immature stages of *kerichoensis* are undescribed.

Dipeolu & Ogunrinade (1977) collected a small number of adults in Nigeria from emergence traps placed at the margins of a dairy cattle drinking trough at the University of Ibadan research farm, and from over cattle dung in an open paddock.

In Kenya, Khamala (1971) collected three females from a high-altitude forest and grassland zone at Kericho. Walker (1976) collected adults from a similar area and from semiarid *Acacia* woodland and grassland. Dipeolu (1976b) collected *kerichoensis* in low numbers in Nigeria from near livestock pens in the forest and Guinea zones.

Braverman & Hulley (1979) predicted the host preference of *kerichoensis* to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Ethiopia, Kenya, Nigeria, South Africa.

**Material Examined.** ETHIOPIA: Kaffa Province, Buba Catholic Mission, about 4 km NE Wush-Wush, V. H. Lee, light trap, 18-20-V-74, 2 ♀♀. KENYA: Kericho, C. Khamala, light trap, 28-XI-66, 1 ♀ paratype. SOUTH AFRICA: Cape, Knysha, E. M. Nevill, 23-IV-71, 1 ♂.

#### *Culicoides krameri* Clastrier

(Fig. 22)

*Culicoides krameri* Clastrier 1959: 194 (female).

Types not given; records from: 6 ♀♀, Bouake, Ivory Coast, P. C. Morel, 21-IX-55; 3 ♀♀, Pakala, Senegal, M. R. Kramer, at light, X-57; 48 ♀♀, Sangalkan, P. C. Morel, 30-X-54; 1 ♀, Nioro, Sudan, P. C. Morel, 10-VIII-55.

*Culicoides ciliodentatus* Khamala & Kettle 1971: 28 (male, female). Holotype: ♀, Tororo, Uganda, C. Khamala, light trap, 17-V-66 (BMNH). Paratypes: 2 ♀♀, same data as holotype (NMK); 5 ♀♀, 5 ♂♂, Entebbe, Uganda, C. Khamala, light trap, 7-IV-66 (1 ♀, 2 ♂♂, BMNH; 1 ♂, MRAC; 4 ♀♀, 2 ♂♂, NMK); 2 ♀♀, 1 ♂, Serere, Uganda, C. Khamala, light trap, 18-V-66 (1 ♀, 1 ♂, USNM; 1 ♀, MRAC).

**Diagnosis.** A medium-sized, brownish species. Female 3rd segment of maxillary palpus slender, with several small, shallow sensory pits on distal surface. Wing pattern similar to that of *milnei*, except wing base dark, with several isolated pale spots; pale spot over r-m crossvein extending to costal margin but not narrowed over radial vein. **Male Genitalia.** Ninth tergum without apicolateral processes; aedeagus with prominent sclerotized bar connecting lateral arms basally; short, slender, anteriorly directed subapical process present arising from just above base of distal median process.

**Female.** Wing length 0.90-1.17 mm ( $n = 3$ ). **Head.** Brown; antennal segments 3-10 broadly pale basally, segments 11-15 narrowly pale basally. Eyes moderately separated by a distance equal to the diameter of 1.5 ocular facets; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 17-13-13-14-15-15-15-16-21-22-22-25-40; A.R. 1.07-1.10 ( $n = 2$ ); sensilla coeloconica (with number per segment) on segments 3(2), 11(1), 12(1), 13(1), 14(1), 15(2). Third segment of maxillary palpus slender, with several small, shallow sensory pits on distal surface; P.R. 2.95-3.58 ( $n = 3$ ). Proboscis long, P/H 0.90-0.97 ( $n = 3$ ); mandible with 19-20 teeth ( $n = 3$ ).

**Thorax.** Brown. Legs brown; femora pale basally, fore- and midfemora paler apically; tibiae each with a basal pale band, mid- and hindtibiae pale apically; hindtibial comb with 5 spines, 2nd from the spur longest. Halter infuscated brown.

**Wing.** Macrotrichia sparse in distal portion of cells. Base of wing dark, with several isolated pale spots; pale spot over r-m crossvein extending to costal margin but not narrowed over radial vein; cell R5 with a pale spot on anterior margin extending over apex of 2nd radial cell; distal ½ of cell R5 with a transverse pale spot, often with a mesal constriction and appearing as 2 spots; cell M1 with a pale spot at middle and a pale spot in distal portion; cell M2 with numerous pale spots, including a spot near base, another just above cubital vein at its midlength, a pale spot just below median fork, a spot just caudad above the cubital fork, and 2 pale spots in distal portion of cell; cell M4 with a small pale spot in distal portion near wing margin; anal cell with an indistinct pale spot at base, a pale spot just below anal vein near its apex, a pale spot at midlength of cell near wing margin, and a pale spot in distal portion near wing margin; wing membrane infuscated grayish brown, darker in basal cell and anterior portion of cell R5; veins brownish. Costal ratio 0.60-0.63 ( $n = 3$ ).

**Abdomen.** Brown. Spermathecae dark brown, unequal, ovoid, with short sclerotized necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.054-0.058 by 0.041 mm and 0.044-0.048 by 0.033-0.037 mm ( $n = 2$ ).

**Male Genitalia.** Ninth tergum with tapering sides, apicolateral processes absent; caudal margin broadly rounded, with a short mesal cleft. Ninth sternum with a very shallow caudomedian emar-



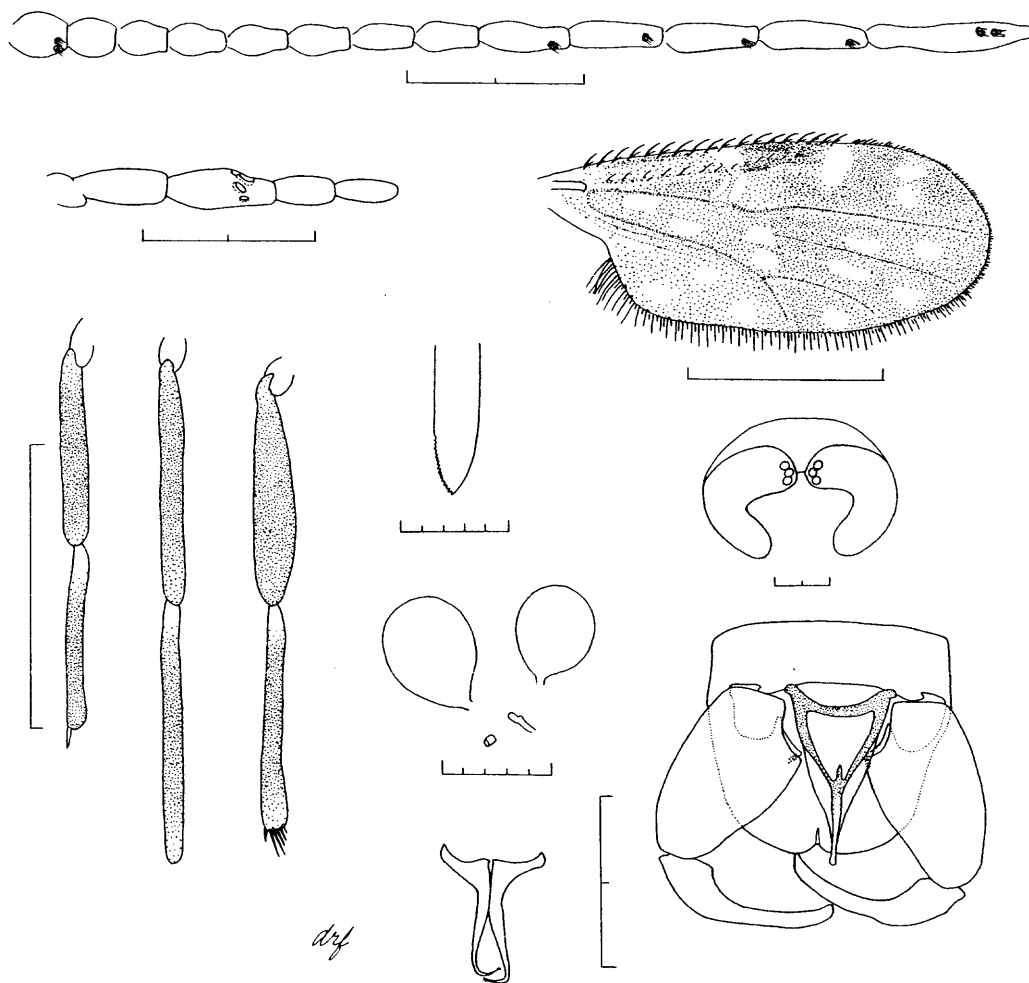


Fig. 22. *Culicoides krameri* (milnei group). Adult female, male genitalia. (See key for scale.)

gination; ventral membrane not spiculate. Basistyle stout, dorsal root short, ventral root absent; dististyle stout over basal  $\frac{1}{3}$ , abruptly curving to a more slender, straight distal portion with bluntly pointed apex. Aedeagus with a strongly sclerotized transverse bar connecting lateral arms at their bases; tapering distally to a long, slender distal median process with rounded apex; lateral margins of distal median process each with a broad, membranous area; aedeagus with a short, slender, anteriorly directed subapical process arising from just above base of distal median process. Parameres separate; base of stem directed anterolaterally; stem distally tapering to a slender, pointed apex with minute setae.

**Discussion.** Kremer (1972b) noted that *ciliodontatus* Khamala & Kettle (1971) is a synonym of *krameri* (nominative form). The synonymy appears to be correct based on a comparison of *krameri* with the male allotype and two male and one female paratypes of *ciliodontatus*. *C. krameri* can be distinguished from the other members of the

group known from Kenya by the dark wing base, which has several isolated pale spots.

**Bionomics.** The immature stages of *Culicoides krameri* are undescribed.

In Nigeria, Dipeolu & Ogunrinade (1976) collected adults emerging from rotten vegetation along the bank of the Opeki River at Eruwa; and at the University of Ibadan research farm (1977) from emergence traps placed along the margins of a dairy cattle drinking trough, at the margins of an open drain leading from a slaughterhouse, and from traps placed over a decomposing grass heap in the vicinity of livestock pens. At the research farm, emergence occurred throughout the year with peaks in June and August.

Khamala (1971) collected numerous adults by light trap in Uganda (as *ciliodontatus* n. sp.) from savannas. Walker (1976) collected *krameri* in Kenya (as *ciliodontatus*) from moist *Combretum* woodland and grassland.

Dipeolu (1976b) collected females in moderate numbers near cattle and small ruminant pens in

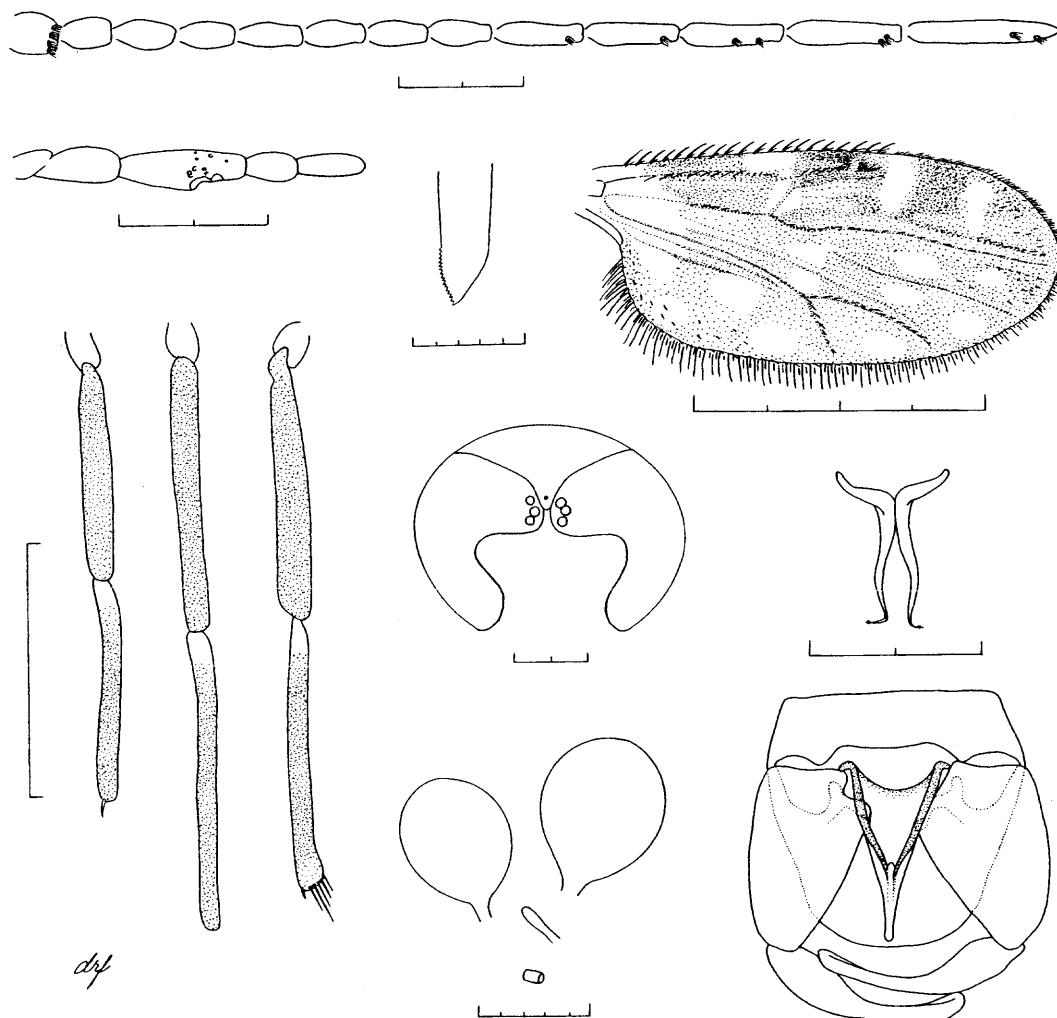


Fig. 23. *Culicoides milnei* (*milnei* group). Adult female, male genitalia. (See key for scale.)

all areas of Nigeria; it was most abundant in the forests, with a period of peak numbers (engorged females) from 0100 to 0300 hours.

Clastrier & Wirth (1961) reported that females were taken while they were biting humans at Abuja, Nigeria, and at M'Bourao, Chad, and on a sticky trap near cattle at Keneba, Gambia. Walker & Boreham (1976) reported the host range of *krameri* (as *ciliodontatus*) to be bovines based on precipitin tests of engorged females. Dipeolu (1978) noted a greater proportion of engorged females were collected in Nigeria from traps set near cattle than near sheep and goats.

**Distribution.** Angola, Chad, Gambia, Ivory Coast, Kenya, Mali, Nigeria, Senegal, Sudan, Uganda.

**Material Examined.** GAMBIA: West Kiang District, Keneba, D. H. Murphy, sticky trap, 1958, 2 ♀♀. UGANDA: Entebbe, C. Khamala, light trap, 7-IV-66, 2 ♂ paratypes (as *ciliodontatus*); Serere,

C. Khamala, light trap, 18-V-66, 1 ♀ paratype, 1 ♂ paratype (as *ciliodontatus*).

#### *Culicoides milnei* Austen (Fig. 23)

*Culicoides milnei* Austen 1909: 283 (female). Holotype: ♀, Nairobi, East Africa Protectorate, 5,000 ft elev., A. D. Milne, 4-V-06. Paratypes: 2 ♀♀, same data as holotype (BMNH).

*Culicoides lugens* Kieffer 1918: 51 (female). Types: Natal, South Africa, New-Hannover (NMH).

*Culicoides rutshuruensis* Goetghebuer 1935b: 174 (male). Holotype: ♂ no. 53 MK, Rutshuru, Belgian Congo, Dr. De Wulf, I-34 (MRAC).

*Culicoides krameri* form *subkrameri* Kremer 1972b: 102 (male, female).

**Diagnosis.** A large, dark-brown species. Female 3rd segment of maxillary palpus slender, with nu-

merous, small sensory pits on distal  $\frac{1}{2}$ . Wing pattern similar to that of *krameri*; base of wing extensively pale, rather than dark with isolated pale spots; pale spot over r-m crossvein extending to costal margin, narrowed over radial vein. **Male Genitalia.** Ninth tergum without apicolateral processes, caudal margin broadly rounded; aedeagus similar to that of *krameri*, with a very short, anteriorly directed, subapical process.

**Female.** Wing length 1.56 mm (1.30–1.81 mm,  $n = 20$ ). **Head.** Dark brown; antenna and 4th and 5th segments of palpus paler brown; antennal segments 3–8 pale basally, more extensive on the more proximal segments, segments 11–15 narrowly pale basally. Eyes narrowly separated by a distance equal to the diameter of about  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 24–19–22–23–24–22–22–23–33–33–38–45–62; A.R. 1.16 (1.06–1.27,  $n = 20$ ); sensilla coeloconica (with number per segment) on segments 3(2–4), 11(1), 12(1–2), 13 (1–2), 14(2), 15(2). Third segment of maxillary palpus slender, with several larger, and numerous small, shallow sensory pits on distal  $\frac{1}{2}$ ; P.R. 3.21 (2.93–3.46,  $n = 20$ ). Proboscis long, P/H 0.91 (0.84–0.95,  $n = 20$ ); mandible with 15 teeth (13–17,  $n = 20$ ).

**Thorax.** Dark brown. Legs brown; femora pale basally; tibiae each with a basal pale band, hindtibia pale at apex; hindtibial comb with 5 spines, the 2nd from the spur longest. Halter infuscated light brown.

**Wing.** Macrotrichia sparse in distal portions of cells. Wing base broadly pale from costal margin caudally into anal cell; pale spot over r-m crossvein extending to costal margin, narrowed over radial vein; cell R5 with a transverse pale spot on anterior margin extending over apex of 2nd radial cell, and a 2nd transverse pale spot in distal portion, often with a mesal constriction; cell M1 with a pale spot at midlength, and a spot more distally; cell M2 with a pale spot just below median fork, a pale spot just above cubital fork, and 2 pale spots in distal portion of cell; cell M4 with a pale spot in distal portion near wing margin; anal cell with a pale spot on posterior margin in basal  $\frac{1}{2}$ , often coalescing with the pale wing base, a pale spot just below apex of anal vein, and a pale spot on posterior margin near apex; membrane infuscated grayish-brown, darker near anterior wing margin, especially in cell R5; wing veins brown. Costal ratio 0.61 (0.59–0.63,  $n = 20$ ).

**Abdomen.** Dark brown. Spermathecae very dark brown, unequal, ovoid, with short necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.074 by 0.054 mm (0.060–0.083 by 0.041–0.060 mm,  $n = 20$ ) and 0.063 by 0.046 mm (0.060–0.071 by 0.041–0.051 mm,  $n = 20$ ).

**Male Genitalia.** Ninth tergum with tapering sides, apicolateral processes absent; caudal margin broadly rounded. Ninth sternum with a broad, moderately shallow caudomedian emargination; ventral membrane not spiculate. Basistyle stout basally,

dorsal root short and stout, ventral root absent; dististyle stout basally, abruptly bent just before midlength, distal portion straight and more slender, expanding to a bluntly rounded apex. Aedeagus with a moderate transverse sclerotization connecting lateral arms basally; sides tapering to a long, slender distal median process with rounded apex; aedeagus with a very short, anteriorly directed subapical process arising from just above base of distal median process. Parameres separate; basal portion of stem directed anterolaterally, main stem nearly straight, tapering to a slender, pointed apex with minute setae.

**Discussion.** Several authors have proposed the synonymy of *milnei* with *austeni* Carter, Ingram & Macfie (i.e., Nicholas et al. 1955, Caeiro 1961). However, Cornet et al. (1974) redescribed these two species as separate entities. Most existing literature on the biology of this complex must be regarded with caution because of the possibility of misidentified material. The description of *austeni* by Khamala & Kettle (1971) is actually that of *zuluensis* De Meillon.

**Bionomics.** Nevill (1969) described and illustrated the fourth instar and pupa of *milnei* from South African material.

In Cameroon, Nicholas et al. (1953, 1955) reared *milnei* from rotting banana and plantain stems and from damp soil containing decaying vegetation (some records may refer to other members of the group). Walker & Davies (1971) found *milnei* larvae in Kenya in habitats characterized as fine mud with a high organic detritus content at the margins of ditches and pools. Lubega & Khamala (1976) reared adults from mud taken from the edges of rivers and streams and from moist soil beneath dense, tall grass during the rainy season. At Eruwa, Nigeria, Dipeolu & Ogunrinade (1976) found *milnei* emerging from boggy ground of a rocky hill site, from crab holes, from other natural or artificial holes, and from rotting vegetation along the banks of the Opeki River. At the University of Ibadan research farm, they (Dipeolu & Ogunrinade 1977) collected adults from emergence traps placed at the margins of a dairy cattle drinking trough, from the margins of an open drain leading from a slaughterhouse, from a decomposing grass heap in the vicinity of livestock pens, and from traps placed over cattle dung in an open paddock. Emergence occurred throughout the year with peaks in June and August. In Zimbabwe, Braverman (1978) reared *milnei* from mud samples taken at the edges of bodies of water in the Salisbury area and from mud low in organic matter along a drainage canal.

Khamala (1971) collected *milnei* in forests and savannas of East Africa (Kenya, Tanzania, and Uganda). Walker (1976) collected adults in Kenya from high-altitude forests and grasslands, moist *Combretum* woodland and grassland, and semiarid *Acacia* woodland and grassland.

The host range of *milnei*, based on precipitin

tests of engorged females, includes horses, cattle, sheep, and birds with a preference for horses (Walker & Davies 1971, Nevill & Anderson 1972, Walker & Boreham 1976). Nicholas et al. (1953, 1955) noted *milnei* to be an important human-biting species in Cameroon (he believed *milnei* and *austeni* to be the same species), giving records of adults attempting to bite in the rainforests and mangrove swamps of Cameroon and in the rainforests and savannas of Nigeria. White (1977) refers to this species as *austeni*.

In Nigeria, Dipeolu (1976b) reported *milnei* from all areas near cattle and small ruminant pens, being the fourth most abundant *Culicoides* (13.2% of total collected). It was the predominant species of *Culicoides* (and the most numerous) in the plateau (90% blood fed); and the third most predominant species in forests (81% blood fed); peak numbers of engorged females occurred from 0300 to 0500 hours. He (Dipeolu 1978) noted that a greater proportion of the females were found engorged in traps set near cattle than near sheep and goats. At the University of Ibadan research farm (Dipeolu et al. 1974), *milnei* was most abundant in the cattle paddock (2% of the population, 80% blood fed), whereas only two females were collected in the sheep and goat paddocks and none in the piggery. Near sites with wild animals (Dipeolu 1976a), it made up 2.5% of the *Culicoides* collected, with the greatest blood-fed numbers from traps around duiker and kob enclosures.

White (1977) found *milnei* to be extremely abundant in Ethiopia biting humans and domestic animals (indoors and outdoors) at Jimma; and widespread elsewhere in the highlands. Its biting cycle was irregular, usually following a succession of ill-defined nocturnal peaks (two or three of progressively greater biting intensity); sometimes it attacked in daylight. Up to 35,000 midges per trap-night were caught in light traps operated in an animal shed containing two cows and one mule; precipitin tests of engorged females showed 71% contained cow's blood, 23% mule's blood, and 6% were negative. Females were frequently abundant in animal shelters, resting by day and biting at night; they rested outdoors in grass tussocks, often in profusion near suitable hosts.

Braverman (1978) found *milnei* to be common in catches made in animal enclosures (horse and chickens) in the Salisbury area of Zimbabwe.

Walker & Davies (1971) considered *milnei* to have a high vector potential for bluetongue virus in Kenya and isolated bluetongue 1 from it during February.

**Distribution.** Angola, Cameroon, Congo, Ethiopia, Guinea, Ivory Coast, Kenya, Nigeria, São Tomé, South Africa, Sudan, Tanzania, Uganda, Zaire, Zimbabwe.

**Material Examined.** ETHIOPIA: Addis Ababa, V. H. Lee home, 2,300 ft elev., V. H. Lee, light trap, 22-23-VIII-74, 1 ♀; Addis Ababa, J. Lane, light trap, X-55, 17 ♀♀, 10 ♂♂; Chida Village, 51 mi

S Jimma, 1,540 ft elev., V. H. Lee, light trap, 15-16-VI-74, 1 ♂; Wallo Province, Kutaber, 23 km NW Dessie, 2,650 m elev., R. W. Ashford, IX-71, 1 ♀, 1 ♂; same data, 7-IX-71, 4 ♀♀; same data, 21-IX-71, 1 ♀; same data, X-71, 3 ♀♀. KENYA: Ngong, near Nairobi, biting man and resting on hut ceiling, R. Heisch, 5-V-64, 40 ♀♀, 2 ♂♂; Nairobi Province, Nairobi, Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 19-V-82, 10 ♀♀; same data, 21-V-82, 1 ♀, 1 ♂; Kabete, Dr. Davies' garden, C. L. Bailey, light trap and CO<sub>2</sub>, 20-V-82, 3 ♀♀. NIGERIA: Abuja, biting man, B. McMillan, 19-VII-56, 3 ♀♀; Diko, indoors, B. McMillan, 5-VII-56, 1 ♀; Du, Jos Plateau, biting man, V. H. Lee, 28-VIII-70, 2 ♀♀; Kaduna, B. McMillan, at light, 25-X-55, 1 ♀. SOUTH AFRICA: Transvaal, Onderstepoort, O. G. H. Fiedler, light trap, 24-I-50, 6 ♀♀. ZAIRE: Gangala Na Bodio, Baker and Schmitt, 29-IV-55, 10 ♀♀. ZIMBABWE: Salisbury, E. T. Reid, light trap, 30-V-56, 2 ♀♀; same data, X-56, 3 ♀♀, 2 ♂♂; same data, 4-XII-56, 3 ♀♀; same data, 13-XII-56, 3 ♀♀, 3 ♂♂; same data, 24-I-57, 3 ♀♀; same data, 2-II-57, 2 ♀♀; same data, 22-II-57, 1 ♀, 1 ♂; same data, 1-III-57, 2 ♂♂; same data, IV-57, 6 ♀♀, 1 ♂; same data, VI-57, 1 ♀.

#### *Culicoides moreli* Clastrier (Fig. 24)

*Culicoides moreli* Clastrier 1959: 189 (male, female). Types: 6 ♀♀, 11 ♂♂, Niokolo-Koba, Senegal, National Park, M. E. Abonnenc, black light trap, 1958; 33 ♀♀, Sangalkam, 10 km from Rufisque, on walls of animal stable, P. C. Morel, 30-X-54; 4 ♀♀, Bouake, 21-IX-55 (IPA).

**Diagnosis.** A medium-sized, brownish species. Female 3rd segment of maxillary palpus slender, with numerous small sensory pits on distal ½; proboscis very long. Wing base broadly pale; pale spot over r-m crossvein narrowed over radial vein; apices of veins M1 and M2 pale; cell M4 with 2 pale spots. **Male Genitalia.** Ninth tergum without apicolateral processes; aedeagus with long, slender, distal median process.

**Female.** Wing length 1.16-1.29 mm ( $n = 2$ ). **Head.** Brown; antennal segments 3-10 broadly pale basally, segments 11-15 narrowly pale basally. Eyes narrowly separated by a distance equal to the diameter of ½ an ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 20-17-17-18-18-18-19-20-26-27-30-34-45; A.R. 1.10; sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(2), 15(2). Third segment of maxillary palpus slender, with numerous small, shallow sensory pits on distal ½; P.R. 3.73. Proboscis very long, P/H 1.00-1.03 ( $n = 2$ ); mandible with 13-15 teeth ( $n = 2$ ).

**Thorax.** Brown. Legs brown; femora pale basally, forefemur pale at apex and through middle to base, midfemur pale at apex; tibiae each with a basal pale band, mid- and hindtibiae pale at apex;

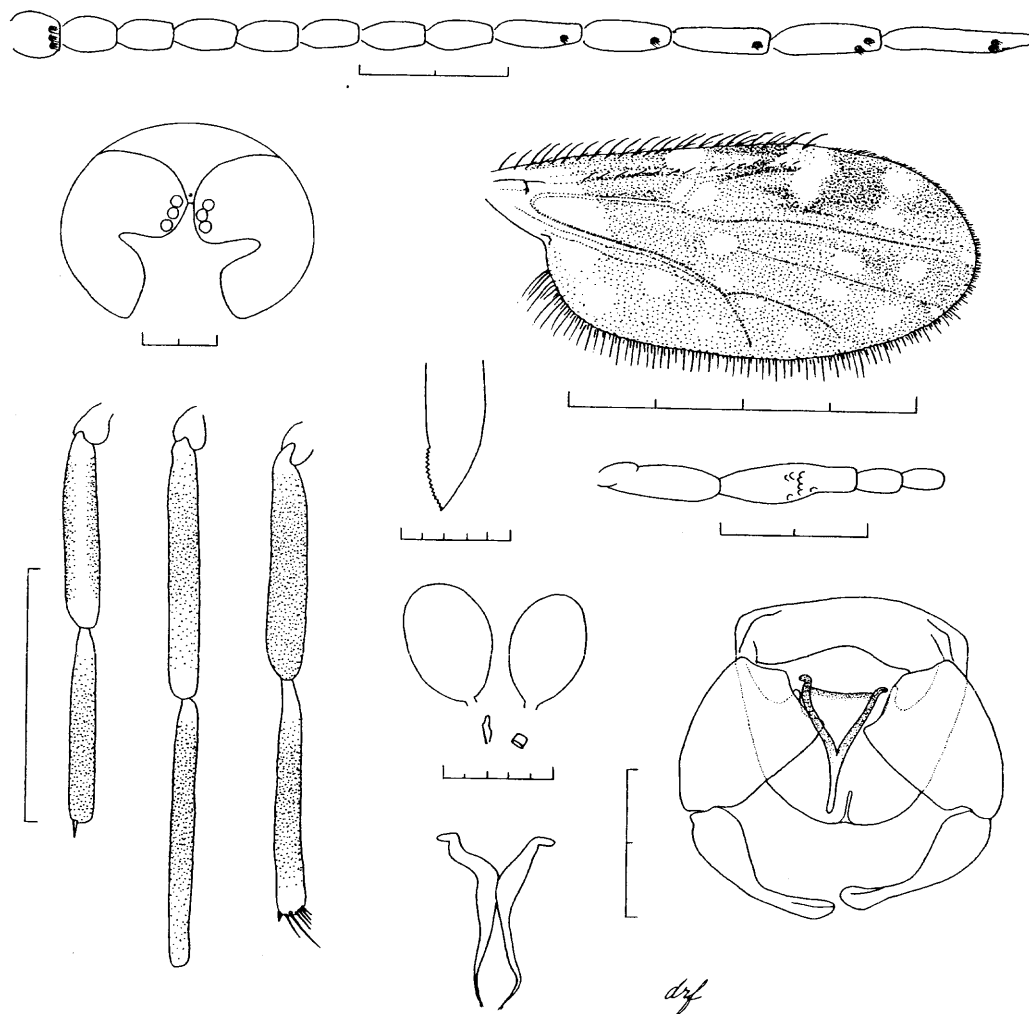


Fig. 24. *Culicoides moreli* (*milnei* group). Adult female, male genitalia. (See key for scale.)

hindtibial comb with 6 spines, the 2nd from the spur longest. Halter infuscated pale brown, knob paler distally.

**Wing.** Macrotrichia very sparse in distal portions of cells. Wing base broadly pale; pale spot over r-m crossvein extending to costal margin, narrowed over radial vein; cell R5 with an irregular transverse pale spot on anterior margin extending over distal portion of 2nd radial cell, and a transverse pale spot in distal portion, constricted at middle and appearing as 2 separate pale spots; cell M1 with a pale spot at midlength, and a 2nd pale spot more distally; cell M2 with a pale spot just below median fork, a spot just above cubital fork, and 2 pale spots in distal portion of cell; cell M4 with 2 small pale spots, 1 near base, and a 2nd in distal portion near posterior wing margin; anal cell with a pale spot in basal portion, coalescing with the pale area at wing base, a pale spot just below and near apex of anal vein, and a pale spot in distal portion of cell near apex; apices of veins M1, M2

and M3+4 pale; membrane infuscated grayish brown, darker near anterior margin of wing, especially in cell R5 between the 2 transverse pale spots. Costal ratio 0.64.

**Abdomen.** Brown. Spermathecae dark brown, slightly unequal, ovoid, with short necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.060–0.061 by 0.038–0.041 mm and 0.055–0.058 by 0.037 mm ( $n = 2$ ).

**Male Genitalia.** Ninth tergum with tapering sides, apicolateral processes absent; caudal margin broadly rounded, with a narrow, deep, median cleft. Ninth sternum with a shallow caudomedian emargination; the ventral membrane not spiculate. Basistyle short and stout; dorsal root short and stout, ventral root absent; dististyle stout basally, with moderate bend at midlength, more slender distally, expanding to a rounded apex. Anterior margin of aedeagus with a moderate transverse sclerotization between the lateral arms; sides of aedeagus tapering to a long, slender, distal median process, apex

rounded; subapical process inapparent. Parameres separate; basal portion of stem anterolaterally directed; distal portion posteriorly directed, nearly straight, tapering to a slender, pointed apex with minute setae.

**Discussion.** *Culicoides moreli* can be distinguished from all other members of the *milnei* group in Kenya by its distinctive wing pattern, the pale apices of veins M1 and M2, and the 2 pale spots in cell M4.

**Bionomics.** The immature stages of *Culicoides moreli* are undescribed.

Lubega & Khamala (1976) reared *moreli* from waterlogged mud from freshwater marshes at Lake Nakuru National Park, Kenya. In Nigeria, Dipeolu & Ogunrinade (1976) found *moreli* adults emerging from boggy ground of a rocky hill site at Eruwa, and at the University of Ibadan research farm, they (Dipeolu & Ogunrinade 1977) collected very small numbers from emergence traps placed at the margins of a dairy cattle drinking trough and over cattle dung in an open dairy paddock.

Khamala (1971) collected adults in Kenya and Uganda from various savanna types. Walker (1976) collected adults in Kenya from moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

Braverman & Hulley (1979) predicted the host preference of *moreli* to be larger mammals based on its low number of antennal sensilla. Dipeolu (1976b) collected *moreli* from all parts of Nigeria near cattle and small ruminant pens, except in the mangrove swamps. Adults were most numerous in the semidesert Sudan zone, where the proportion of gravid females in light trap collections was significantly highest (Dipeolu 1978). He (1976b) noted that in the Guinea and Sudan zones (northern), it appeared to replace the closely related *C. quinque-lineatus*, blood-fed females making up 66–87% of collections near cattle with peak numbers from 0100 to 0300 hours.

**Distribution.** Gambia, Ivory Coast, Kenya, Madagascar, Nigeria, Senegal, Sudan, Uganda.

**Material Examined.** GAMBIA: West Kiang District, Keneba, wet soil at well, D. H. Murphy, 23-X-59, 1 ♂; same locality, D. H. Murphy, sticky trap, 23-X-59, 1 ♀. KENYA: No locality given, A. R. Walker, 1971–1974, 1 ♀, 1 ♂.

### *Culicoides zuluensis* De Meillon

(Fig. 25)

*Culicoides zuluensis* De Meillon 1936: 145 (female). Holotype: ♀, Gingindhlovu, Zululand, III-30 (IMRJ).

*Culicoides acastus* De Meillon 1947: 118 (male). Holotype: ♂, Mooiplaats, Transvaal, R. du Toit, at light, 18-IV-44 (IMRJ).

**Diagnosis.** A large, dark brown species. Female eyes contiguous; 3rd segment of maxillary palpus

very slender, with several small, shallow sensory pits. Wing base broadly pale from costal margin to posterior margin of anal cell; a very large, quadrangular pale spot over r-m crossvein, extending broadly to costal margin; apex of wing with a narrow pale band; apex of vein M2 dark. **Male Genitalia.** Ninth tergum without apicolateral processes; aedeagus with a long, slender, distal median process; parameres separate.

**Female.** Wing length 1.50 mm (1.43–1.68 mm,  $n = 6$ ). **Head.** Dark brown; segments 4 and 5 of maxillary palpus paler; antennal segments 3–10 broadly pale basally, segments 11–15 narrowly pale basally. Eyes contiguous for a distance equal to the diameter of about 1.5 ocular facets; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 24–18–20–21–22–21–21–23–29–29–33–38–55; A.R. 1.08 (0.99–1.16,  $n = 6$ ); sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(2), 15(2). Third segment of maxillary palpus long and very slender, with a slight swelling at midlength, distal portion with several small, shallow sensory pits; P.R. 3.77 (3.54–4.00,  $n = 5$ ). Proboscis long, P/H 0.96 (0.95–0.98,  $n = 4$ ); mandible with 14 teeth (13–15,  $n = 6$ ).

**Thorax.** Dark brown. Legs brownish; femora pale basally, forefemur pale at apex and through middle to base, midfemur pale at apex; tibiae each with a pale subbasal band, appearing almost basal on mid- and hindlegs, foretibia darker at base, mid- and hindtibiae pale at apex; hindtibial comb with 5 spines, the 2nd from the spur longest. Halter stem and basal portion of knob infuscated pale brown.

**Wing.** Macrotrichia sparse in distal portions of cells. Base of wing with a broad pale area extending from costal margin, through basal  $\frac{1}{3}$  of anal cell to posterior wing margin; a very large, quadrangular pale spot over r-m crossvein, extending broadly to costal margin, and narrowly into cell M2, coalescing with the basal pale area; cell R5 with a large, irregular, transverse pale spot on anterior margin, extending over distal portion of 2nd radial cell, and with a transverse pale spot in distal portion of cell; cell M1 with a pale spot at midlength and a 2nd more distally; cell M2 with a pale spot just below median fork, a spot just above cubital fork, and 2 distal pale spots; cell M4 with a small pale spot in distal portion near wing margin; anal cell with a pale spot mostly below apex of anal vein, and with a pale spot near apex of cell; apex of wing with a narrow pale band along margin, from just past distal pale spot in cell R5 to just above vein M2; apex of vein M2 dark; membrane infuscated grayish brown, darker near anterior margin of wing, especially in cell R5; veins brown. Costal ratio 0.60 (0.58–0.61,  $n = 6$ ).

**Abdomen.** Dark brown. Spermathecae very dark brown, unequal, ovoid, with short necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.060 by 0.041 and 0.053 by 0.040 mm.

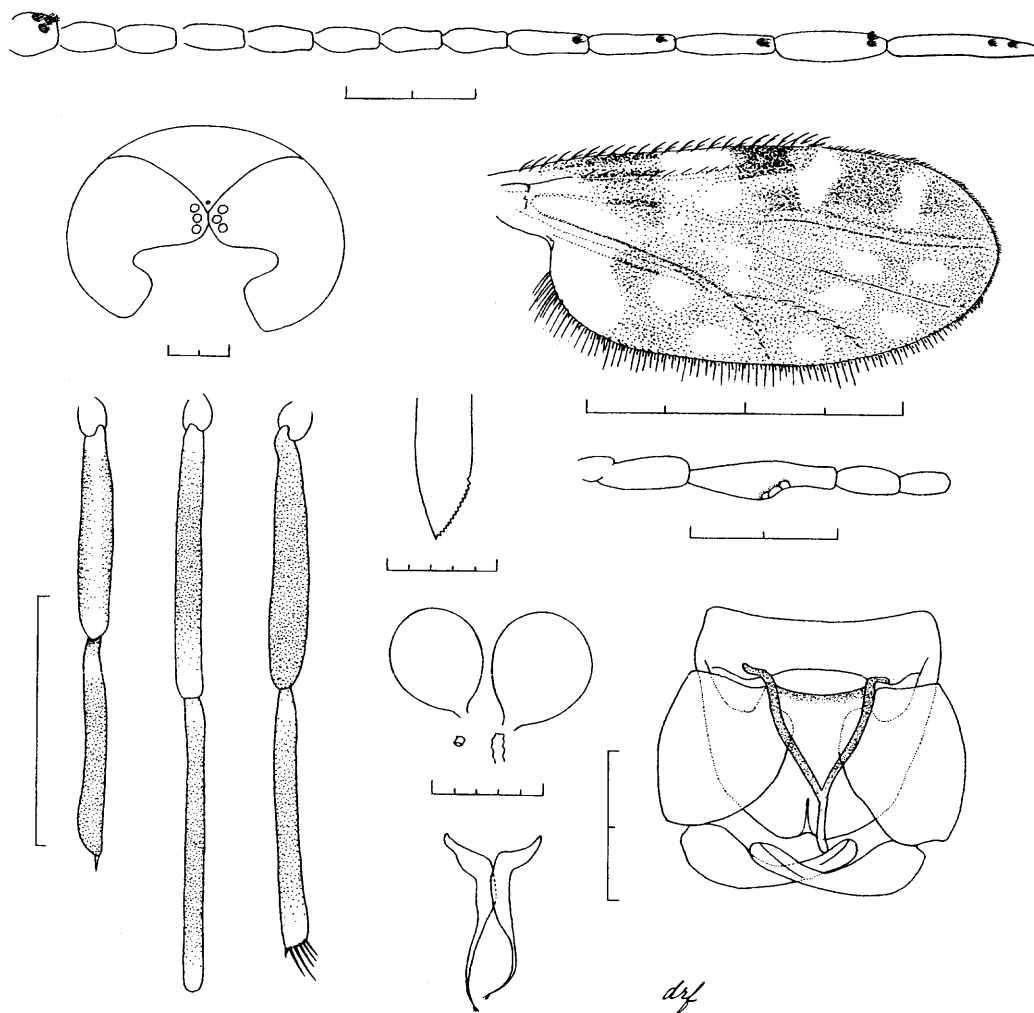


Fig. 25. *Culicoides zuluensis* (*milnei* group). Adult female, male genitalia. (See key for scale.)

**Male Genitalia.** Ninth tergum with tapering sides, apicolateral processes absent; caudal margin broadly rounded, with a narrow, deep mesal cleft. Ninth sternum with a shallow caudomedian emargination; the ventral membrane not spiculate. Basistyle short and very broad; dorsal root short and stout, ventral root absent; dististyle stout basally, abruptly bent at midlength, distal portion straight, more slender, expanding to a bluntly rounded apex. Aedeagus with a moderate transverse sclerotization on anterior margin between the lateral arms; sides of aedeagus tapering to a long, slender, distal median process, apex rounded; subapical process apparently absent. Parameres separate; basal portion of stem directed anterolaterally; main stem posteriorly directed, slightly curving, tapering distally to a slender, pointed apex with minute setae.

**Discussion.** *Culicoides zuluensis* can be distinguished from the other members of the *milnei* group in Kenya by the large, quadrangular pale spot over the r-m crossvein (which extends to the

costal margin), and the narrow pale band at the apex of the wing.

Khamala & Kettle (1971) described *austeni* Carter, Ingram & Macfie from Kenya and Tanzania; however, their illustration of the wing clearly shows they had collected *zuluensis* instead. *C. austeni* has not yet been recorded from Kenya.

**Bionomics.** The immature stages of *zuluensis* are undescribed.

In Kenya, Lubega & Khamala (1976) reared *zuluensis* (as *austeni*) from habitats similar to those of *milnei*, including mud taken from the edges of rivers and streams and from moist soil beneath dense, tall grass during the rainy season. Braverman (1978) reared *zuluensis* in the Salisbury area of Zimbabwe from mud taken around a puddle rich in organic matter; from along streams and drainage canals poor in organic matter; and from cow dung, especially over wet soil. Adults were common in suction light trap catches in animal enclosures (horses and chickens).

Khamala (1971) collected *zuluensis* (as *austeni*) in Kenya from savannas and in Tanzania from densely cultivated savannalike communities derived from forest. Walker (1976) collected adults in Kenya from high-altitude forest and grassland; moist *Combretum* woodland and grassland; semi-arid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

Walker & Boreham (1976) reported that the host range of *zuluensis* included birds, goats, sheep and horses based on precipitin tests of blood-engorged females.

**Distribution.** Kenya, South Africa, Zimbabwe.

**Material Examined.** KENYA: Nairobi Province, Nairobi, Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 19-V-82, 2 ♀♀; same data except C. L. Bailey and Kairo, light trap and CO<sub>2</sub>, 25-V-82, 1 ♀; no locality given, A. R. Walker, 1971-1974, 2 ♂♂. ZIMBABWE: Salisbury, E. T. Reid, light trap, 30-V-56, 1 ♀; same data, 24-I-57, 3 ♀♀; same data, VIII-57, 2 ♀♀, 1 ♂.

### *Culicoides neavei* Group

**Diagnosis.** Female eyes narrowly to moderately separated. Female antennal sensory pattern variable, usually 3, 10-14, 3, 11-14, or 3, 11-15. Female 3rd segment of maxillary palpus with a single, large sensory pit. Hindtibial comb with 4 spines. Wing with numerous, well-defined pale spots; 2nd radial cell dark to apex; macrotrichia abundant. Female abdomen with 2 functional spermathecae and a rudimentary 3rd, sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with well-developed apicolateral processes; dorsal and ventral roots of basistyle long and simple; aedeagus with deep basal arch, distal median process with truncate apex; parameres separate, stem with laterally directed basal knob, distally tapering to a simple, pointed apex.

**Kenya Species.** *C. neavei* Austen, *C. ovalis* Khamala & Kettle.

### *Culicoides neavei* Austen (Fig. 26)

*Culicoides neavei* Austen 1912: 102 (female). Holotype: ♀, vic. Kumi, Umro, Uganda Protectorate, 3,700 ft elev., S. A. Neave, 16-18-VIII-11 (BMNH).

*Culicoides multiguttata* Goetghebuer 1935b: 156 (female; as *Forcipomyia*; misident., in part). Paratype: ♀ no. 48 MK, Vitshumbi, Belgian Congo, Dr. De Wulf, X-33 (MRAC).

**Diagnosis.** A medium-sized, dark brown species. Female distal antennal segments elongated; sensilla coeloconica on antennal segments 3, 10-14; 3rd segment of maxillary palpus with a shallow sensory pit. Wing with a large transverse pale spot in cell R5 on anterior margin just distad of and extending caudally well below the 2nd radial cell; distinct

pale spots near base of cell M1 and just below in cell M2, and in distal portion of cells R5, M1, M2, M4, and anal cell; distal pale spots in cells M1 and M2 not extending to wing margin. **Male Genitalia.** As in the group diagnosis; distal median process of aedeagus long and stout.

**Female.** Wing length 1.11 mm (0.98-1.33 mm,  $n = 13$ ). **Head.** Dark brown. Eyes narrowly to moderately separated by a distance equal to the diameter of about  $\frac{1}{2}$  to 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 20-11-12-13-13-13-14-25-27-26-28-38; A.R. 1.39 (1.18-1.51,  $n = 12$ ); sensilla coeloconica (with number per segment) on segments 3(4-6), 10(1), 11(1-2), 12(1-3), 13(1-2), 14(4-8). Third segment of maxillary palpus moderately expanded, with a large, rounded, shallow sensory pit; P.R. 2.55 (2.16-2.86,  $n = 13$ ). Proboscis moderately short, P/H 0.76 (0.63-0.88,  $n = 13$ ); mandible with 13 teeth (11-16,  $n = 13$ ).

**Thorax.** Dark brown. Legs brown; femora pale basally, fore- and midfemora pale apically; tibiae each with a subbasal pale band, paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia abundant over most of wing. Wing with a large pale spot over r-m crossvein, extending anteriorly to costal margin; cell R5 with a large, transverse pale spot on anterior margin just distal to and extending caudally well below the 2nd radial cell, and with a smaller pale spot at apex of cell; cell M1 with an elongate spot near base, and a rounded spot at apex; cell M2 with pale spots near base, proximal to cubital vein at its midlength, below median fork, in distal portion below basal spot of cell M1, and at apex; distal pale spots in cells M1 and M2 not extending to wing margin; cell M4 with a pale spot in distal portion proximal to wing margin; anal cell with a diffuse pale area in basal portion, and a double transverse pale spot in distal portion. Costal ratio 0.57 (0.54-0.60,  $n = 13$ ).

**Abdomen.** Dark brown. Spermathecae dark brown, slightly unequal, ovoid, with very short necks; rudimentary 3rd narrow; sclerotized ring moderately short; functional spermathecae 0.055 by 0.042 mm (0.046-0.068 by 0.037-0.048 mm,  $n = 7$ ) and 0.050 by 0.041 mm (0.045-0.060 by 0.037-0.045 mm,  $n = 7$ ).

**Male Genitalia.** Ninth tergum with moderately tapering sides and long, stout apicolateral processes; caudal margin with a short mesal emargination. Ninth sternum with a broad, deep caudomedian emargination; ventral membrane not spiculate. Dorsal root of basistyle moderately long and stout, ventral root long and slender with pointed apex; dististyle stout, curving from just past base, distal portion straight, with curved, bluntly pointed apex. Aedeagus with a deep, rounded basal arch, bases of lateral arms curved laterally; distal median process long and stout, sides nearly parallel, apex truncate. Paramere with laterally directed basal knob,



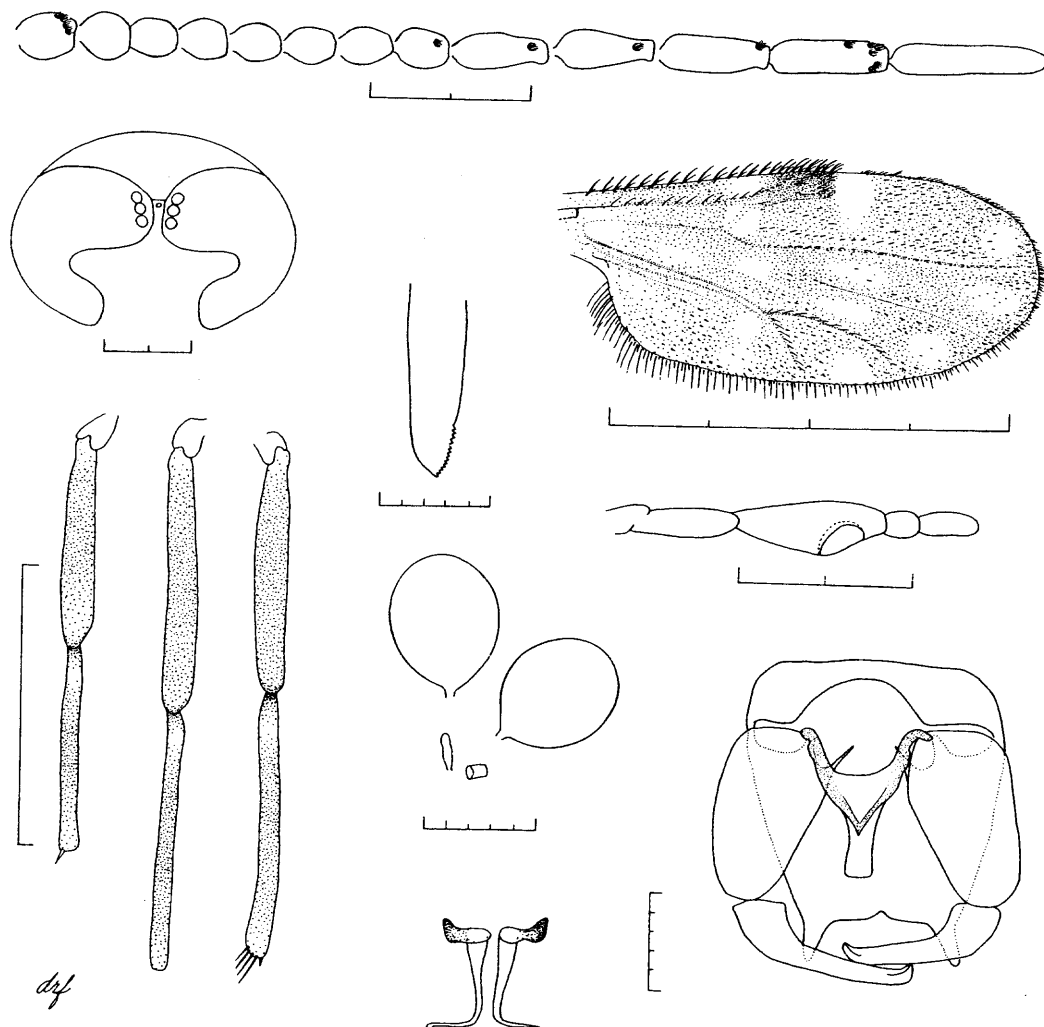


Fig. 26. *Culicoides neavei* (neavei group). Adult female, male genitalia. (See key for scale.)

stem straight, tapering, distally curving to a laterally directed, slender, pointed apex.

**Discussion.** *Culicoides neavei* can be distinguished from *ovalis* Khamala & Kettle by the wing pattern and antennal sensory pattern. Khamala & Kettle (1971) placed *confusus* Carter, Ingram & Macfie and *coarctatus* Clastrier & Wirth in the *neavei* group; however, these species are not members of the group, especially because of the differences in wing patterns, antennal sensory patterns, and male genitalia.

Kremer et al. (1973) placed *neavei* in their *odibilis* group (about 36 species) subgroup *odibilis* (I), characterized by pale spots on the distal border of the wing, a pale spot in the base of cell M1, and the entirely dark second radial cell.

**Bionomics.** Ingram & Macfie (1921) described the pupa from two exuviae isolated from adults reared at Accra, Ghana, from soft mud taken from the edges of pools and puddles. The larva of *neavei* is undescribed.

Nicholas et al. (1955) reared many adults from soil taken at the base of a tree in a forest at Kumba, Cameroon. Callot et al. (1967a) reared a male and female from a substrate sample of mud taken from a stream bed pond serving as an animal watering site at Ethiolo, Senegal. In Kenya (Khamala 1975, Lubega & Khamala 1976), *neavei* was reared at Lake Nakuru National Park from immatures collected from water-logged mud with decaying vegetation in a *Cyperus* marsh. At Eruwa, Nigeria, Dipeolu & Ogunrinade (1976) found *neavei* emerging from boggy ground of a rocky hill site and from rotten vegetation, crab holes, and other natural or artificial holes along the bank of the Opeki River. At the University of Ibadan research farm, they (Dipeolu & Ogunrinade 1977) found adults most numerous in emergence traps placed at the margins of a dairy cattle drinking trough; adults also were collected in very small numbers from emergence traps over cattle dung in an open paddock and from the margins of an open drain

leading from a slaughterhouse. Emergence continued throughout the year, with peaks in June and August. Braverman (1978) reared *neavei* in Salisbury, Zimbabwe, from mud samples taken around a puddle rich in organic matter and along drainage canals from mud low in organic matter; adults were obtained from May to July and October to December.

Clastrier & Wirth (1961) reported adults taken by light trap in Gambia from a palm scrub and rice swamp at Mandarini, from a forest canopy at Lamin, and from a sticky trap near cattle at Keniba. In East Africa, Khamala (1971) reported *neavei* was relatively abundant in the forests and savannas of Kenya, Tanzania, and Uganda. Walker & Davies (1971) noted that *neavei* had a relatively low distribution within the bluetongue enzootic area of Kenya. Walker (1976) collected adults in Kenya from high-altitude forest and grassland, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, and arid *Acacia-Commiphora* bushland.

Austen (1912) and Macfie (1947) recorded females taken in Sudan while biting humans. Braverman & Hulley (1979) predicted the host preference of *neavei* to be larger mammals based on the low number of antennal sensilla. Nevill & Anderson (1972) reported that a blood-fed female was shown by precipitin test to have fed on birds.

Dipeolu (1976b) collected *neavei* in moderate numbers near livestock pens by light trap from all areas of Nigeria except the mangrove swamps; it was most numerous in the forests, with peak numbers of engorged females collected from 0100 to 0300 hours. At the University of Ibadan research farm (Dipeolu et al. 1974), *neavei* (as the *neavei* group) was collected in a cattle paddock (30% blood fed), a piggery (25% blood fed), and in sheep and goat paddocks (45% blood fed). During the day, they were caught by sticky traps in many areas but were most abundant in the sheep and goat grazing areas (all blood engorged). It also was collected in high numbers from sites near wild animals (Dipeolu 1976a).

**Distribution.** Angola, Cameroon, Congo, Ethiopia, Gambia, Ghana, Guinea, Kenya, Madagascar, Mali, Nigeria, Senegal, South Africa, Sudan, Tanzania, Uganda, Upper Volta, Zaire, Zimbabwe.

**Material Examined.** ETHIOPIA: Illubabor Province, Gambela, L. Sholdt, light trap and CO<sub>2</sub>, XI-73, 4 ♀♀; same data except 1,748 ft elev., W. L. Schmitt, light trap, XI-68, 5 ♀♀; same data, VIII-71, 5 ♀♀. GAMBIA: West Kiang District, Keniba, D. H. Murphy, light trap, 16-VII-56, 1 ♀; same data, 12-VIII-57, 1 ♀; same data except sticky trap, 1958, 2 ♀♀, 1 ♂; North Kombo District, Lamin, forest, D. H. Murphy, light trap, 12-II-60, 3 ♀♀, 2 ♂♂; Mandinari, swamp, D. H. Murphy, light trap, 15-II-60, 3 ♀♀. KENYA: Rift Valley Province, Marigat, D. Young and R. Beach, light trap, 7-10-VII-81, 1 ♀. SOUTH AFRICA: Natal, Merrivale District, Pietermaritzburg, B. Stuckenberg, light trap, I-80, 1

♀, 2 ♂♂; same data, V-80, 1 ♀. ZIMBABWE: Salisbury, E. T. Reid, light trap, IX-56, 1 ♂; same data, X-56, 2 ♀♀, 1 ♂; same data, VI-57, 1 ♀; same data, VIII-57, 1 ♀.

### *Culicoides ovalis* Khamala & Kettle

(Fig. 27)

*Culicoides ovalis* Khamala & Kettle 1971: 88 (male, female). Holotype: ♀, Mombasa, Kenya, C. Khamala, light trap, 19-VII-66 (BMNH). Paratypes: 3 ♂♂, same data as holotype (1 ♂, BMNH; 1 ♂, MRAC; 1 ♂, NMK); 8 ♀♀, 2 ♂♂, Zika Forest, Uganda, C. Khamala, light trap, 5-V-66 (1 ♀, 1 ♂, BMNH; 1 ♀, 1 ♂, USNM; 1 ♀, MRAC; 5 ♀♀, NMK).

**Diagnosis.** A medium-sized, brownish species. Female eyes very narrowly separated; distal antennal segments elongate; sensilla coeloconica on antennal segments 3, 11-14; 3rd segment of maxillary palpus with a moderately shallow sensory pit. Wing pattern very similar to that of *neavei*; pale spot on anterior margin of cell R5 small and rounded, not extending caudally much below radial cell; distal pale spots in cells M1 and M2 extend to wing margin. Female abdomen with 2 slightly unequal spermathecae, without sclerotized necks. **Male Genitalia.** As in the group diagnosis; similar to *neavei*, distal median process of aedeagus shorter and very broad.

**Female** (from single paratype). Wing length 1.06 mm. **Head.** Brown. Eyes very narrowly separated by a distance less than the diameter of ½ an ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 23-17-16-17-17-17-18-35-35-38-39-50; A.R. 1.39; sensilla coeloconica (with number per segment) on segments 3(4), 11(1), 12(1), 13(1), 14(5-6). Third segment of maxillary palpus moderately swollen, with a large, rounded, moderately shallow sensory pit; P.R. 2.19. Proboscis short, P/H 0.60; mandible with 11 teeth.

**Thorax.** Brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band, slightly paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter infuscated pale brown.

**Wing.** Macrotrichia abundant over most of wing. Wing pattern very similar to that of *neavei*; pale spot on anterior margin of cell R5 small and rounded, not extending caudally much beyond radial cell; pale spot in cell M2 below basal spot in cell M1 reduced; distal pale spots in cells M1 and M2 extend to wing margin; distal pale spot in anal cell not doubled. Costal ratio 0.57.

**Abdomen.** Brown. Spermathecae brown, slightly unequal, ovoid, without sclerotized necks; rudimentary 3rd narrow; sclerotized ring moderately short; functional spermathecae 0.068 by 0.045 and 0.065 by 0.044 mm.

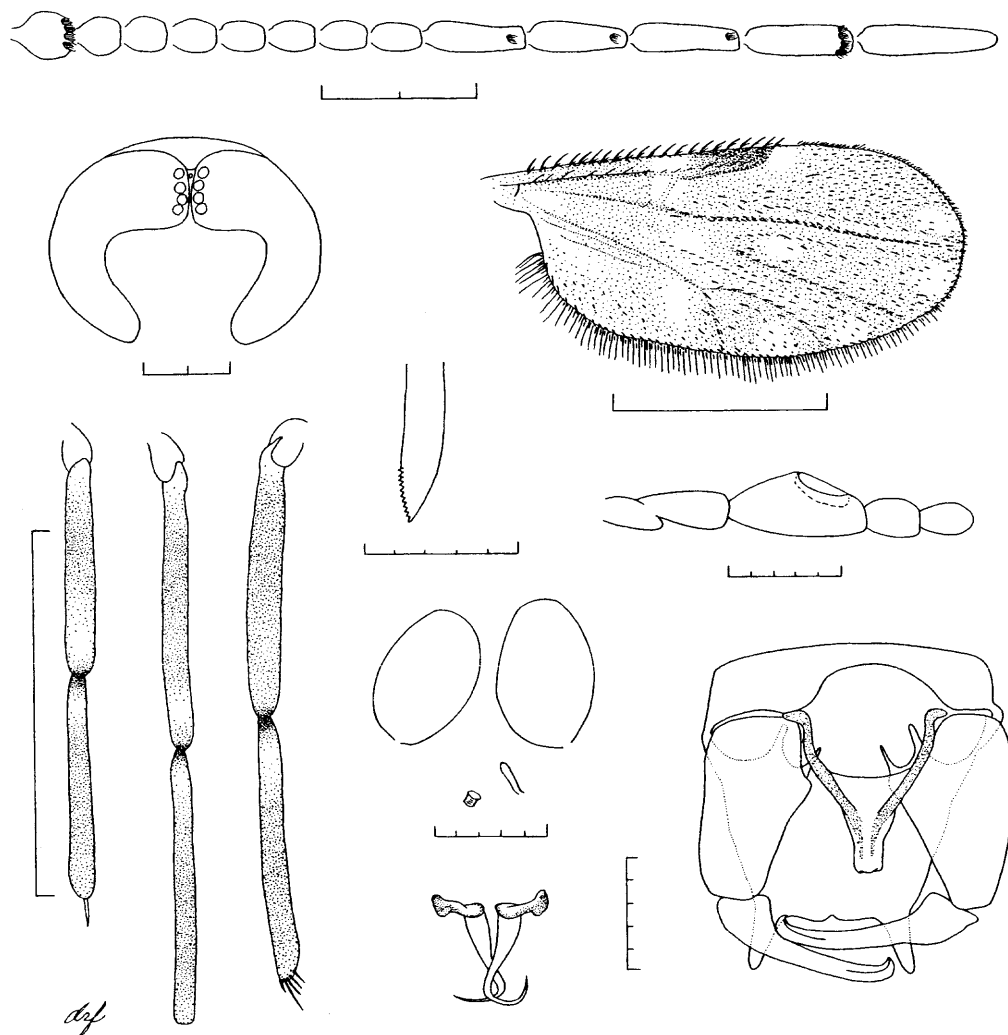


Fig. 27. *Culicoides ovalis* (*neavei* group). Adult female, male genitalia. (See key for scale.)

**Male Genitalia.** Very similar to that of *neavei*. Dorsal root of basistyle more slender. Aedeagus with deep basal arch, lateral arms more slender; distal median process shorter and stouter.

**Discussion.** *Culicoides ovalis* can best be distinguished from *neavei* by the smaller pale spot on the anterior margin of cell R5; the distal pale spots in cells M1 and M2 (extending to the wing margin); and by its antennal sensory pattern of 3, 11-14 rather than 3, 10-14.

**Bionomics.** The immature stages of *Culicoides ovalis* are undescribed.

At Eruwa, Nigeria, Dipeolu & Ogunrinade (1976) found *ovalis* adults emerging from rotten vegetation along the bank of the Opeki River. Khamala (1971) collected several adults in East Africa, including one from a savanna in Kenya and three from the Zika Forest in Uganda. In Nigeria, Dipeolu (1976b) collected adults in low numbers by light trap near livestock pens in the forest and

derived savanna, northern Guinea, and Sudan zones. Braverman & Hulley (1979) predicted the host preference of *ovalis* to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Kenya, Nigeria, Uganda.

**Material Examined.** UGANDA: Zika Forest, C. Khamala, light trap, 5-V-66, 1 ♀ paratype, 1 ♂ paratype.

#### *Culicoides nigripennis* Group

**Diagnosis.** Large, brownish species. Female eyes narrowly separated; without interfacetal setae. Female proximal antennal segments elongate, distal antennal segments greatly elongated; sensilla coeloconica usually on segments 3, 5, 7, 9, 11-15. Female 3rd segment of maxillary palpus distally expanded, with a single, large sensory pit. Hindtibial comb with 4 spines. Wing with 2 pale spots, 1 over the r-m crossvein, not extending to costal margin,

the other on anterior margin just distad of 2nd radial cell; macrotrichia abundant over most of wing. Female abdomen with 2 functional spermathecae, usually subspherical, with long sclerotized necks, and a rudimentary 3rd; sclerotized ring present at junction of ducts. *Male Genitalia*. Ninth tergum with long apicolateral processes; 9th sternum with caudomedian emargination, ventral membrane not spiculate; basistyle with long, simple dorsal and ventral roots; basal portion of dististyle usually greatly expanded; aedeagus with deep basal arch; distal median process short, apex variable; parameres separated; stem tapering distally to a simple, pointed apex.

**Kenya Species.** C. sp. 7.

***Culicoides* sp. 7**  
(Fig. 28)

**Diagnosis.** A large, dark-brown species. Female eyes very narrowly separated; sensilla coeloconica on antennal segments 3, 5, 7, 9, 11–15. Wing with pale spots over r-m crossvein and on anterior margin just distad of 2nd radial cell. Female abdomen with functional spermathecae subspherical, with long, narrow, tapering necks. *Male Genitalia*. Distal median process of aedeagus moderately short, slender, with rounded apex; inner margin of basistyle with a large subbasal lobe; basal ½ of dististyle greatly enlarged, bulbous, densely covered with very long, spinose setae.

**Female.** Wing length 1.44 mm (1.34–1.54 mm,  $n = 20$ ). **Head.** Dark brown; antenna and 4th and 5th segments of maxillary palpus lighter brown; antennal segments 3–10 pale on basal ½, segments 11–15 narrowly pale at bases. Eyes very narrowly separated by a distance less than the diameter of ½ an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 31–23–24–25–26–26–28–29–61–57–62–64–81; A.R. 1.53 (1.44–1.64,  $n = 19$ ); sensilla coeloconica (with number per segment) on segments 3(5–7), 5(1), 7(1), 9(1), 11(1), 12(1), 13(1), 14(2–3), 15(2). Third segment of maxillary palpus moderately expanded at midlength, with a large, rounded, moderately shallow sensory pit; P.R. 2.42 (2.30–2.57,  $n = 20$ ). Proboscis moderately long, P/H 0.75 (0.71–0.82,  $n = 20$ ); mandible with 19 teeth (18–22,  $n = 20$ ), proximal margin (basal 3–6 teeth) slightly expanded.

**Thorax.** Dark brown; mesonotum without pattern. Legs brown; hindfemur and all tibiae dark brown; tarsi pale, except hindbasitarsus brownish; femora very narrowly pale at bases, fore- and mid-femora each with a subapical pale band, forefemur paler along middle from subapical pale band to base; tibiae each with a subbasal pale band, mid- and hindtibiae narrowly pale at apex; hindtibial comb with 4 spines, the 2nd from the spur slightly longer than the 1st. Halter infuscated brown.

**Wing.** Macrotrichia brown, long and dense over most of wing except at extreme wing base and in

costal cell. Wing membrane pale brownish, basal cell and anterior margin of cell R5 infuscated darker brown; wing veins brown, vein M2 somewhat paler, veins forming the 2 radial cells darker. Wing with 2 small, rounded pale spots, 1 over the r-m crossvein, not extending into cell M2 or anteriorly to the costal margin, and a 2nd spot in cell R5 on anterior margin just distad of the 2nd radial cell, extending only slightly below the level of Rs. Costal ratio 0.59 (0.58–0.61,  $n = 20$ ).

**Abdomen.** Dark brown. Spermathecae brown, subspherical, slightly unequal, with long, narrow, tapering sclerotized necks; rudimentary 3rd short and narrow, with a slight distal expansion; sclerotized ring short; functional spermathecae (less necks) 0.102 by 0.099 mm (0.092–0.111 by 0.091–0.103 mm,  $n = 16$ ) and 0.095 by 0.090 mm (0.083–0.105 by 0.083–0.099 mm,  $n = 20$ ); rudimentary 3rd 0.034 mm long (0.028–0.041 mm,  $n = 16$ ); sclerotized ring 0.018 mm long (0.014–0.026 mm,  $n = 12$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, stout, pointed apicolateral processes; caudal margin with a moderately deep mesal cleft. Ninth sternum with a moderately broad, deep caudomedian emargination; the ventral membrane not spiculate. Inner margin of basistyle with a large subbasal lobe; dorsal root long and stout with truncate apex, ventral root long and slender, tapering to a pointed apex; basal ½ of dististyle greatly enlarged, bulbous, densely covered with very long, spinose setae; dististyle abruptly narrowed at midlength, distal ½ moderately curved, apex bluntly pointed. Aedeagus with a broad, very deep basal arch, lateral arms slender, slightly expanded at bases and recurved anteriorly; distal median process moderately short, slender, slightly expanded distally with rounded apex. Paramere with angulate basal knob; stem sinuate, expanded at midlength, tapering distally and curving laterally to a simple, pointed apex.

**Discussion.** *Culicoides nigripennis* Carter, Ingram & Macfie is a complex of >13 species which present good characters only in the male genitalia (females are difficult to separate) (Cornet, personal communication). The female holotype of *nigripennis* is difficult to characterize; the male described as *eriodendroni* (Ingram & Macfie 1921) is actually the male of *nigripennis*. Cornet noted that *lamborni* Ingram & Macfie is difficult to characterize because the slides in the BMNH are in poor condition, and that *Culicoides rageaui* Vattier & Adam does not correspond to any of the species he has collected. *C. rageaui* as redescribed by Kremen from the female is probably *nigripennis*.

Vattier & Adam (1966) described *rageaui* from material collected by light trap in Meya-Nzouari Cave at Brazzaville, Congo. Their illustration of the male genitalia is somewhat similar to that of species 7. However, the shapes of the distal median process of the aedeagus and that of the dististyle of *rageaui* are somewhat different than in species

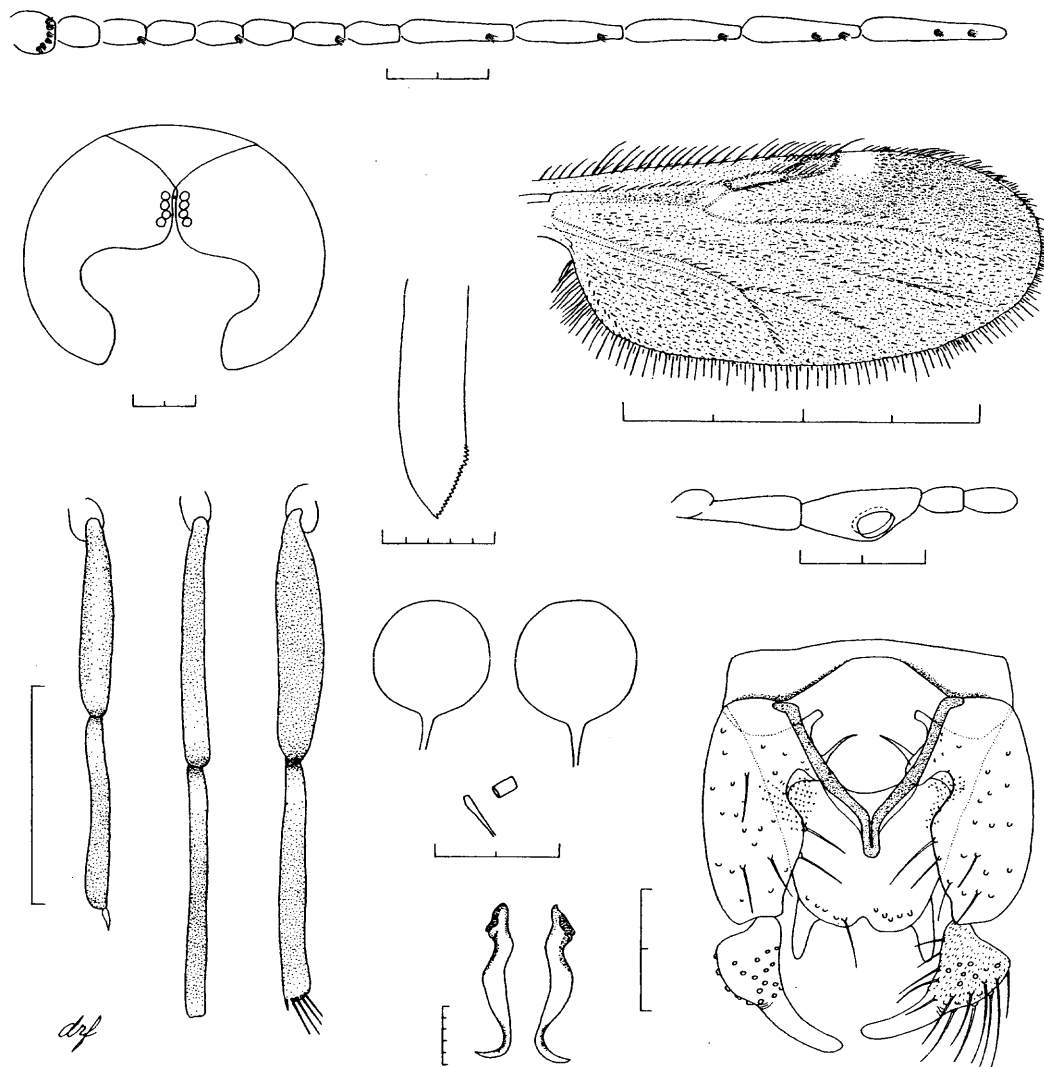


Fig. 28. *Culicoides* sp. 7 (*nigripennis* group). Adult female, male genitalia. (See key for scale.)

7; they did not show whether a basal inner process on the basistyle was present.

Ingram & Macfie (1925) described *lamborni* from two males (apparently reared) collected at Fort Johnston, Nyasaland (Malawi), a port community near the southern tip of Lake Nyasa. They also described the pupa from an isolated exuvium. Their descriptions of the adult male are similar to that of species 7; however, adult material of *lamborni* was not available for comparison. No differences could be found between pupal exuviae of species 7 and the description of the pupa of *lamborni*.

**Bionomics.** Carter et al. (1920) described the larva and pupa of *nigripennis*; Ingram & Macfie (1925) described the pupa of *lamborni*.

The *nigripennis* group breeds predominantly in tree rot holes and other artificial containers. Carter et al. (1920) found nine pupae of *nigripennis* in a rot hole of a mango tree (*Mangifera* sp.) in Ghana.

Ingram & Macfie (1921) reared the male (as *eriodendroni*) from a rot hole in the stump of a silk-cotton tree. In Zimbabwe, Braverman (1978) reared adults (as the *nigripennis* group) from rot holes of the jacaranda (*Jacaranda mimosifolia* D. Don) and the Persian lilac (*Melia azedarach* L.) in the Salisbury area. Walker (1976) collected adults (as *nigripennis*) in Kenya from arid *Acacia-Commiphora* bushland.

*Culicoides* sp. 7 was reared from giant African snail shells (*Achatina fulica* Bowdich) collected in Ukunda, Coastal Province, Kenya. Although the shells appeared to be dry, the larvae apparently survived in a thin film of water held in the deepest whorls of the shell. It is assumed they normally feed on the dead snail and other detritus that may accumulate in the shell. The shells varied from about 5 to >13 cm in length with the greatest number of larvae found in the larger (>10 cm)

shells. Shells collected during the first half of June and flooded on 1 July produced adults from 24 July to 2 September. Larvae could withstand prolonged dry periods because several adults were obtained from shells that were collected in June but not flooded until early December. In all cases, larvae obtained within 24 h after flooding of the shells were mature.

**Distribution.** Kenya.

**Material Examined.** KENYA: Coastal Province, Mombasa, Ukunda, near Coverdale property, sea level, C. L. Bailey, reared from giant African snail shells collected 5-9-VI-82, flooded 1-VII-82 (all adults with associated pupal exuviae): 24-VII-82, 1 ♀; 28-VII-82, 1 ♀; 6-VIII-82, 3 ♀♀; 9-VIII-82, 3 ♀♀, 1 ♂, 4 larvae; 11-VIII-82, 12 ♀♀; 13-VIII-82, 10 ♀♀, 1 ♂; 16-VIII-82, 5 ♀♀; 17-VIII-82, 1 ♀; 18-VIII-82, 1 ♀, 1 larva; 19-VIII-82, 2 ♀♀; 20-VIII-82, 3 ♀♀; 24-VIII-82, 4 larvae; 27-VIII-82, 1 ♀; 30-VIII-82, 1 ♂; 31-VIII-82, 3 ♀♀, 5 larvae; 1-IX-82, 3 ♀♀; 2-IX-82, 1 ♀.

*Culicoides schultzei* Group

**Diagnosis.** Female eyes narrowly to moderately separated. Female antenna with sensilla coeloconica usually on segments 3, 8-10. Third segment of maxillary palpus with a single, rounded sensory pit. Hindtibial comb with 4 spines, that nearest the spur longest. Wing with prominent pattern of distinct pale spots; 3 or 4 pale spots in cell R5; radial cells absent; macrotrichia moderately abundant. Female abdomen with 2 functional spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with well-developed apicolateral processes; 9th sternum with a deep caudomedian emargination, the ventral membrane spiculate; basistyle with long dorsal and ventral roots; aedeagus with a broad, deep basal arch, distal median process stout with truncate apex; parameres separate, stem moderately slender and recurved distally, apex with short setae.

**Kenya Species.** *C. rhizophorensis* Khamala & Kettle, *C. schultzei* (Enderlein), *C. sp. 4*, *C. sp. 5*, *C. sp. 6*.

*Culicoides rhizophorensis* Khamala & Kettle  
(Fig. 29)

*Culicoides rhizophorensis* Khamala & Kettle 1971: 77 (male, female). Holotype: ♀, Mombasa, Kenya, C. Khamala, light trap, 23-VII-66 (BMNH). Paratypes: 12 ♀♀, 12 ♂♂, same data as holotype (1 ♀, 2 ♂♂, BMNH; 1 ♀, 1 ♂, USNM; 1 ♀, 1 ♂, MRAC; 9 ♀♀, 8 ♂♂, NMK).

**Diagnosis.** A moderately large, brownish species. Female eyes moderately separated. Male antennal segment 11 with a short sensillum trichodeum, segments 7 and 9 each with 1 long and 1 short sensilla

trichodea. Wing with 2 pale spots in cell M4, an elongate spot proximal to vein M3+4, and a rounded pale spot at wing margin, the 2 spots often coalescing; apices of veins not prominently pale. **Male Genitalia.** Similar to other member of the group; apicolateral processes slender, widely separated; dististyles stout, only gradually tapering distally, dististyles stout, only gradually tapering distally, densely covered with setae to apex.

**Female.** Wing length 1.12-1.20 mm ( $n = 2$ ). **Head.** Brown. Eyes moderately separated by a distance slightly greater than the diameter of 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 26-17-17-18-18-19-19-20-30-30-32-35-44; A.R. 1.09-1.12 ( $n = 2$ ); sensilla coeloconica (with number per segment) on segments 3(3), 8(3), 9(3), 10(4). Third segment of maxillary palpus moderately expanded, with a large, rounded, moderately shallow sensory pit; P.R. 2.18-2.53 ( $n = 2$ ). Proboscis moderately long, P/H 0.81-0.92 ( $n = 2$ ); mandible with 15-16 teeth ( $n = 2$ ).

**Thorax.** Brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band, fore- and midtibiae pale at apices, hindtibia pale on apical  $\frac{1}{3}$ ; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse on distal  $\frac{1}{2}$  of wing and in distal portion of anal cell. Wing markings similar to those of other members of the group; cell M4 with 2 pale spots, an elongate spot lying proximal to vein M3+4 at its midlength, and a rounded pale spot proximal to posterior wing margin, the 2 spots often coalescing; apices of veins not prominently pale. Costal ratio 0.55-0.56 ( $n = 2$ ).

**Abdomen.** Brown. Spermathecae slightly unequal, ovoid, with very short necks; rudimentary 3rd slightly expanded; sclerotized ring short; functional spermathecae 0.062 by 0.039 and 0.055 by 0.037 mm.

**Male.** **Head.** Antennal segment 11 with a short sensillum trichodeum, segments 7 and 9 each with 1 long and 1 short sensilla trichodea. **Male Genitalia.** Similar to other members of the group; apicolateral processes relatively short, slender, widely separated; caudal margin of 9th tergum with a slight mesal emargination; dististyle stout, gradually tapering distally, densely covered with setae to apex.

**Discussion.** *Culicoides rhizophorensis* males are easily distinguished by hairy dististyles. The females are more difficult to separate, especially because the two pale spots in cell M4 may be confluent.

**Bionomics.** The immature stages of *Culicoides rhizophorensis* are undescribed. In Kenya, Lubega & Khamala (1976) reared *rhizophorensis* from intertidal mud in mangrove swamps and other coastal marshes.

Braverman & Hulley (1979) predicted the host preference of *rhizophorensis* to be larger mammals based on the low number of antennal sensilla.

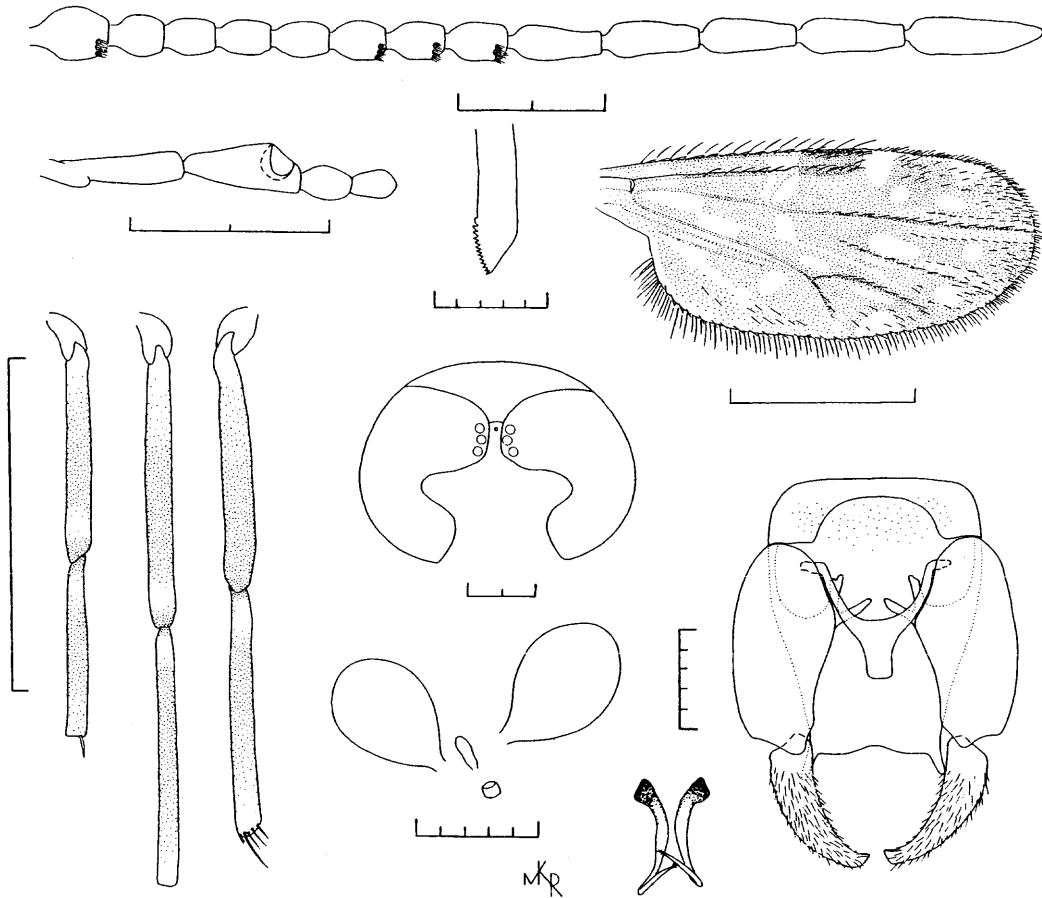


Fig. 29. *Culicoides rhizophorensis* (*schultzei* group). Adult female, male genitalia. (See key for scale.)

**Distribution.** The distribution of *rhizophorensis* is uncertain. The species is known from three mangrove zones, including the Kenya type locality, the Comoro Islands, and Madagascar; and from the coastal zone of the Cape Province, South Africa, where there is no mangrove (Cornet, personal communication).

**Material Examined.** KENYA: Mombasa, C. Khamala, light trap, 23-VII-66, 1 ♀ paratype, 1 ♂ paratype. SOUTH AFRICA: South Cape, Knysna, E. M. Nevill, 6-I-72, 1 ♀ (Cornet no. 3820), 1 ♂ (Cornet no. 3817).

***Culicoides schultzei* (Enderlein)**  
(Fig. 30)

*Ceratopogon schultzei* Enderlein 1908: 459 (male, female). Types not specified. Type locality: Rooibank (Hinterland of Walfisch Bay), German South-West Africa, V-05.

*Culicoides schultzei* (Enderlein); Carter, Ingram & Macfie 1920: 231 (male, female, larva, pupa; Ghana) (BMNH).

*Culicoides irroratus* Goetghebuer 1948: 12 (female). Holotype: ♀ no. 28 MK, May ya Moto,

Belgian Congo, 950 m elev., G. F. de Witte, 15-III-34. Paratypes: ♀ no. 32 MK, ♂ no. 35 MK, same data as holotype; ♀ no. 33 MK, same data as holotype except 9-III-34 (MRAC).

*Culicoides kingi* of Khamala & Kettle 1971: 76 (misident.; male, female; Kenya, Tanzania, Uganda).

**Diagnosis.** A moderately large, brownish species. Female eyes moderately separated. Female 3rd segment of maxillary palpus greatly expanded. Male antennal segment 11 without a sensillum trichodeum, segments 7 and 9 each with 1 long and 1 short sensilla trichodea. Wing pattern similar to other members of the group; large, elongate pale spots above and below middle of vein M2; cell M4 with 2 pale spots, 1 proximal to vein M3+4, the other in distal portion proximal to wing margin; apices of veins M1, M2, M3+4, and Cu1 pale. **Male Genitalia.** Similar to other members of the group; apicolateral processes very large, broad, closely approximated basally, curving laterally from bases and tapering to slender apices, separated by a distinct caudomedian notch; ventral root of basistyle with a fairly distinct anterior process; aedeagus broad, basal arch not very deep, somewhat

V-shaped, lateral arms stout; distal median process of aedeagus very broad, tapering to a truncate apex.

**Female.** Wing length 0.97–1.33 mm ( $n = 2$ ).

**Head.** Brown. Eyes moderately separated by a distance equal to the diameter of about 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 26–21–20–21–21–21–22–22–30–30–33–36–50; A.R. 0.97–1.03 ( $n = 2$ ); sensilla coeloconica (with number per segment) on segments 3(2), 8(2), 9(2), 10(3). Third segment of maxillary palpus greatly expanded, with a large, rounded, moderately deep sensory pit; P.R. 1.82–2.00 ( $n = 2$ ). Proboscis moderately long, P/H 0.78–0.89 ( $n = 2$ ); mandible with 12–17 minute teeth ( $n = 2$ ).

**Thorax.** Brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band, fore- and midtibiae broadly pale at apices, hindtibia pale on apical  $\frac{1}{2}$ ; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse on distal  $\frac{1}{2}$  of wing and in distal portion of anal cell. Wing pattern similar to other members of the group; large, elongate pale spots above and below middle of vein M2; cell M4 with 2 pale spots, 1 proximal to vein M3+4, the other in distal portion proximal to wing margin; apices of veins M1, M2, M3+4, and Cul pale. Costal ratio 0.50–0.51 ( $n = 2$ ).

**Abdomen.** Brown. Spermathecae slightly to moderately unequal, ovoid, with very short necks; rudimentary 3rd narrow; sclerotized ring moderately short; functional spermathecae 0.059–0.099 by 0.037–0.070 mm and 0.055–0.086 by 0.034–0.063 mm ( $n = 2$ ).

**Male.** **Head.** Antennal segment 11 without a sensillum trichodeum, segments 7 and 9 each with 1 long and 1 short sensilla trichodea. **Male Genitalia.** Similar to other members of the group; apicolateral processes very large and broad, closely approximated basally, curving laterally from bases and tapering to slender, nearly pointed apices, separated by a distinct caudomedian notch; ventral root of basistyle with a fairly distinct anterior process; aedeagus broad, with a moderately deep, somewhat V-shaped basal arch, lateral arms stout; distal median process very broad, tapering to a truncate apex.

**Discussion.** The wing pattern of *schultzei*, as illustrated by Enderlein, contains two pale spots in cell M4; however, most redescriptions are of material having only one pale spot in cell M4 and could refer to any one of several other species in the *schultzei* group. Because of this confusion in the literature, it is difficult to determine in many cases what information applies to true *schultzei*. Further difficulties arise with information reported for the "*schultzei* group" (as in Braverman [1978] for Zimbabwe), or for the "*kingi* group" (which often refers to a species other than *kingi*). Much of the *kingi*, *kingi* group, and *schultzei* material

described from Egypt (Macfie 1924, 1943; Nagaty & Morsy 1960a,b,c; 1961a,b; 1962a,b; Nagaty et al. 1965a,b), Israel (Callot et al. 1969; Braverman & Galun 1973b; Braverman et al. 1974, 1976, 1981), Iran (Mesghali 1963; Navai & Mesghali 1968; Navai 1970, 1971), Iraq (Khalaf 1957, 1961), and Afghanistan and Pakistan (Navai 1977) refers to *Culicoides mesopotamiensis* Patton, a highly variable species (Cornet, personal communication).

True *schultzei* has not yet been confirmed from West Africa (west of Lake Chad), but it is widely distributed in South and East Africa (Cornet, personal communication).

**Bionomics.** Nevill (1969) described and illustrated the fourth instar and pupa (as *schultzei*) from South African material. Early rearing and collection records of *schultzei* in Ghana (Carter et al. 1920, Macfie & Ingram 1923) and later records for Gambia (Clastrier & Wirth 1961), Nigeria (Clastrier & Wirth 1961, Dipeolu et al. 1974, Lee 1979), and Kenya (Walker 1976, 1977) probably refer mostly to another species (i.e., sp. 4). Material reported from Senegal, Mali, and Upper Volta (Cornet 1969) as *schultzei* and *kingi* probably comprises several species other than *schultzei* (according to wing illustrations, etc.).

In Kenya (Khamala 1975, Lubega & Khamala 1976), *schultzei* (?) has been reared from mud taken from salty marshes at Lake Nakuru and from decaying pieces of logs on the lake shore edge. Khamala (1971) collected adults (as *kingi*) by light trap from a densely cultivated savannalike zone derived from forest (Tanzania) and from a dry bushland and thicket zone (Kenya).

The host range (as *schultzei*), based on precipitin tests of engorged females, includes cattle, sheep, and goats with a preference for cattle (Nevill & Anderson 1972, Walker & Boreham 1976, Braverman et al. 1977). In South Africa, Nevill & Anderson (1972) noted that it was most abundant in a poultry house trap and second in abundance in a cattle trap. Records of *schultzei* biting humans in Zaire (De Meillon 1937), Guinea (Callot et al. 1964), and Madagascar (De Meillon 1961) might refer to true *schultzei*.

**Distribution.** Savannas of South and East Africa to Lake Chad; not yet found in West Africa west of Lake Chad (Cornet, personal communication). Confirmed from Kenya, South Africa, and Tanzania.

**Material Examined.** SOUTH AFRICA: North Cape, Hopetown, E. M. Nevill, 6-III-70, 1 ♀ (Cornet no. 3795); Orange, "Danielskuil," Bloemfontein, E. M. Nevill, 6-IV-76, 1 ♂ (Cornet no. 4073).

#### *Culicoides* sp. 4

(Fig. 31)

**Diagnosis.** A medium-sized, brownish species. Female eyes narrowly separated. Male antennal segment 11 with a short sensillum trichodeum, segments 7 and 9 each with 1 long and 1 short sensilla



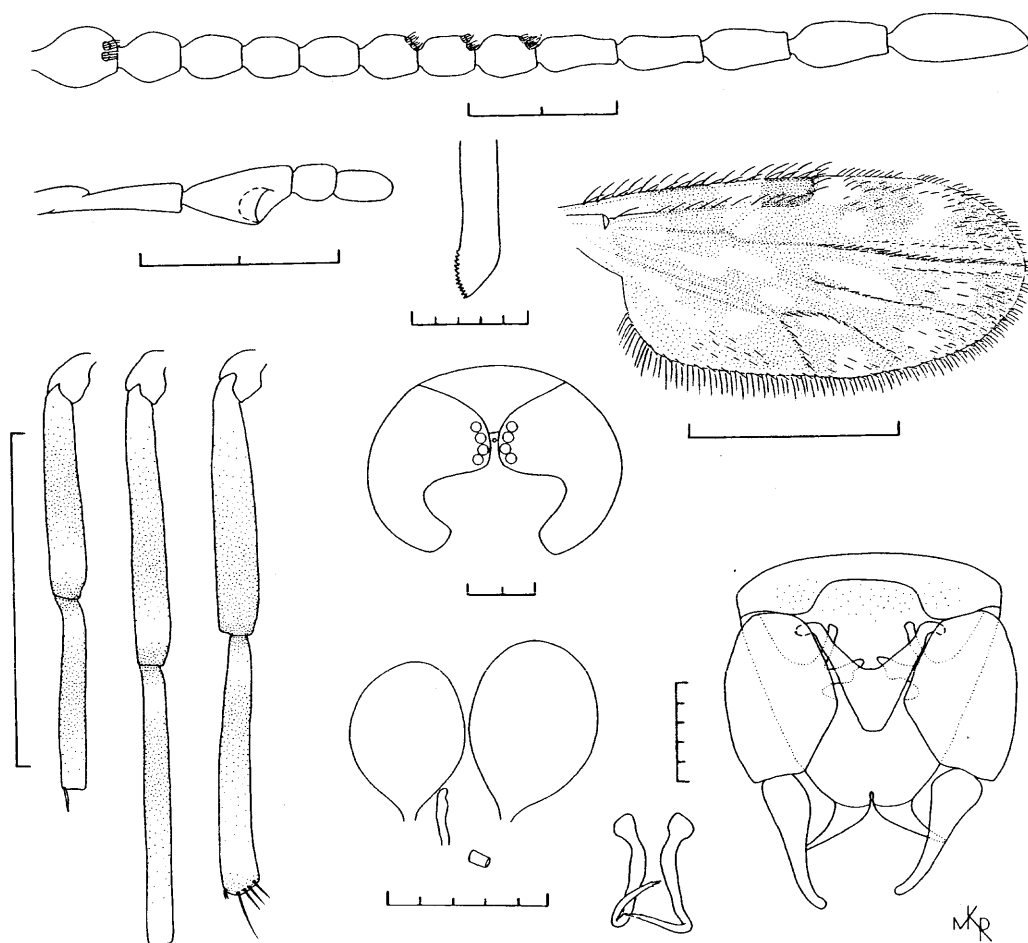


Fig. 30. *Culicoides schultzei* (*schultzei* group). Adult female, male genitalia. (See key for scale.)

trichodea. Wing markings somewhat reduced; pale spot above middle of vein M2 small, ovoid; 1 pale spot in cell M4, proximal to vein M3+4 and not extending to wing margin; distal portion of veins M1, M2, M3+4, and Cul pale-margined to apices. **Male Genitalia.** Apicolateral processes large and stout, triangulate, closely approximated; ventral root of basistyle with a vague anterior process; distal median process of aedeagus short and stout with slightly tapering sides, apex truncate.

**Female.** Wing length 0.97 mm (0.78–1.17 mm,  $n = 19$ ). **Head.** Brown. Eyes narrowly separated by a distance equal to the diameter of about  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 18–12–13–14–14–14–15–16–20–21–22–23–35; A.R. 1.04 (0.95–1.12,  $n = 17$ ); sensilla coeloconica (with number per segment) on segments 3(2–3), 8(1), 9(1–2), 10(2–3). Third segment of maxillary palpus moderately expanded, with a large, rounded, moderately shallow sensory pit; P.R. 2.40 (2.00–2.65,  $n = 18$ ). Proboscis moderately long, P/H 0.84 (0.76–0.94,  $n = 18$ ); mandible with 12 teeth (11–14,  $n = 18$ ).

**Thorax.** Brown. Legs brown, knees darker; femora pale basally, each with a subapical pale band, indistinct on hindfemur; tibiae each with a well-defined subbasal pale band, fore- and midtibiae broadly pale apically, hindtibia pale on apical  $\frac{1}{2}$ ; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia long and sparse over most of wing. Pale spots reduced; a large transverse pale spot over r-m crossvein extending anteriorly to costal margin; cell R5 with a moderately large pale spot on anterior margin just distad of radial vein, and a smaller spot just below and distal to the former; distal  $\frac{1}{2}$  of cell R5 with 2 pale spots, a moderately large spot on anterior margin, and a smaller spot just below and slightly proximad of the former; cell M1 with a moderately large, rounded pale spot just above middle of vein M2, and a smaller spot in distal portion of cell; cell M2 with small pale spots at base, just above middle of cubital vein, just below median fork, just above cubital fork, and in distal portion of cell; cell M4 with a moderately large, elongate pale spot proximal to vein M3+4 and extending to middle of cell;

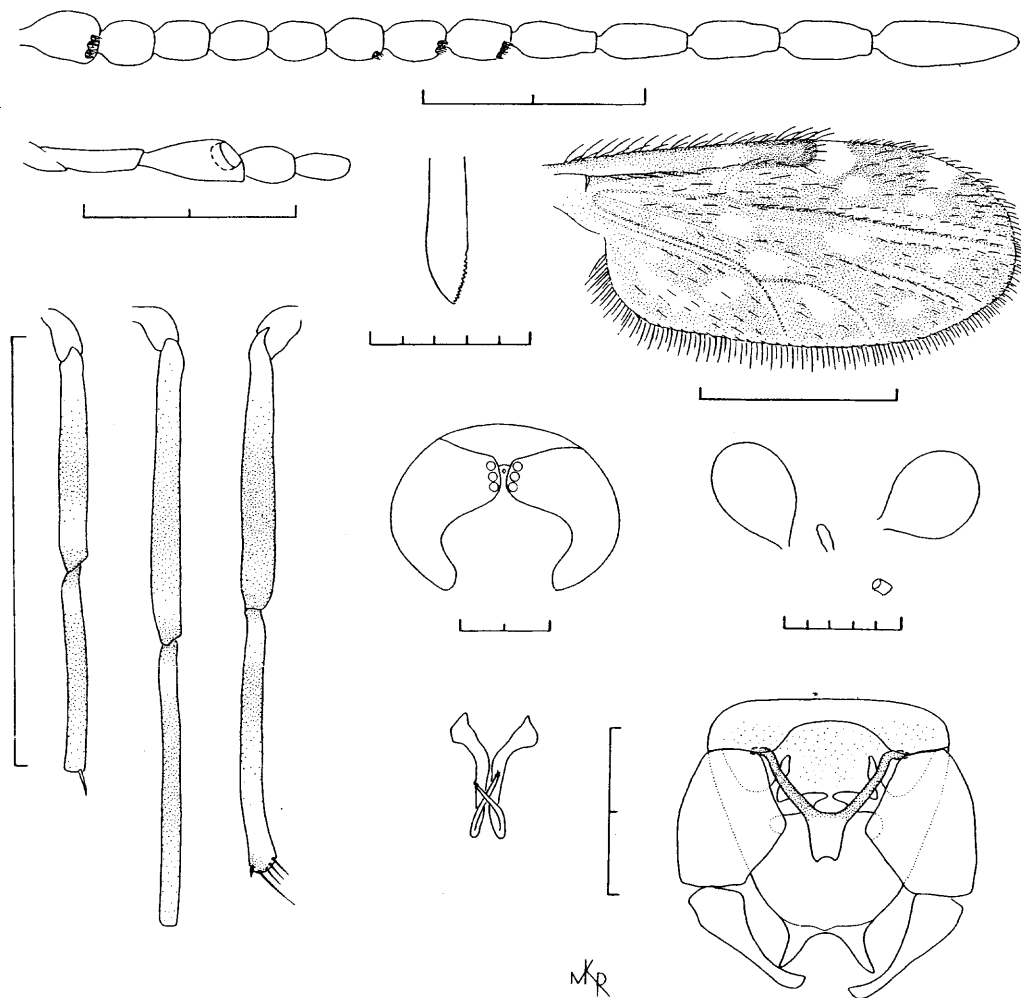


Fig. 31. *Culicoides* sp. 4 (*schultzei* group). Adult female, male genitalia. (See key for scale.)

anal cell with a small, rounded pale spot near base, an elongate, diffuse pale area in middle of cell, and a large, rounded pale spot in distal portion just below apex of anal vein; distal portion of veins M1, M2, M3+4, and Cu1 prominently pale-margined to apices. Costal ratio 0.53 (0.52–0.55,  $n = 19$ ).

**Abdomen.** Brown. Spermathecae subequal to slightly unequal, ovoid, with very short necks; rudimentary 3rd short and narrow; sclerotized ring moderately short; functional spermathecae 0.050 by 0.034 mm (0.041–0.065 by 0.028–0.044 mm,  $n = 17$ ) and 0.047 by 0.033 mm (0.038–0.065 by 0.026–0.041 mm,  $n = 17$ ).

**Male. Head.** Antennal segment 11 with a short sensillum trichodeum, segments 7 and 9 each with 1 long and 1 short sensilla trichodea. **Male Genitalia.** Ninth tergum with tapering sides; apicolateral processes large and stout, moderately triangulate, closely approximated, with pointed apices. Ninth sternum with a broad, deep caudomedian emargination; the ventral membrane spiculate. Dorsal root of basistyle long and moderately slen-

der; ventral root stout, directed mesally, with a vague anterior process; dististyle broad at base, tapering to middle, distally slender with a slightly expanded, bluntly pointed apex. Aedeagus with a deep, rounded basal arch; arms slender, with short, laterally directed bases; distal median process short and stout with slightly tapering sides, apex truncate. Paramere with anterolaterally directed basal knob; stem moderately slender, tapering distally and recurved ventrally to a long, slender, pointed apex with microscopic setae.

**Discussion.** *Culicoides* sp. 4 can be distinguished from the other members of the *schultzei* group in Kenya by the single pale spot in cell M4, which is situated proximal to vein M3+4 and does not extend to the wing margin. The male genitalia are virtually indistinguishable from those of spp. 5 and 6.

Most redescriptions of *schultzei* concern specimens with one pale spot in cell M4, whereas *schultzei*, as illustrated by Enderlein (1908), has two pale spots in cell M4. It is difficult to ascertain

which published data relates to sp. 4 and which to true *schultzei*, but much of the literature since Enderlein's description probably refers to either sp. 4 or one of the several other members of the complex. Clastrier's (1959) description and wing illustration of the female (as *schultzei*) conforms to sp. 4 from Senegal, Upper Volta, and the Ivory Coast. Khamala & Kettle's (1971) description of *schultzei* from Kenya, Tanzania, and Uganda ("easily recognized by 1 pale spot in cell M4") corresponds to sp. 4, whereas their *kingi* from Kenya and Tanzania is true *schultzei*. Dipeolu (1976b, 1977) noted he was using Khamala & Kettle's (1971) keys for the identification of Nigerian material, so it is likely that at least some of their *schultzei* group collections refer to sp. 4 (reported as *schultzei* group species A in Boorman & Dipeolu 1979). Most other information reported by authors as *schultzei* or the *schultzei* group is discussed under *schultzei* (Enderlein 1908).

**Bionomics.** The immature stages of sp. 4 are undescribed.

Khamala (1975) and Lubega & Khamala (1976) described adults (as *schultzei*) reared from immatures collected in a variety of habitats at Lake Nakuru National Park, Kenya, including mud and wet soil from river edges, from mud mixed with bird excreta on the lake edge, from water-logged mud with decaying vegetation in a *Cyperus* marsh, from wet soil at the edges of rainwater pools in *Hyperrhenia-Chloris* grasslands, and from mud at edges of artificial drainage ditches.

Khamala (1971) reported adults (as *schultzei*) to be widely distributed in East Africa in the forest, savanna, grassland, and dry bushland and thicket zones of Kenya, Tanzania, and Uganda. Walker & Davies (1971) reported high densities of *schultzei* (probably mostly sp. 4) outside of the bluetongue enzootic area of Kenya.

Dipeolu (1976b) collected adults (as *schultzei*) in large numbers from all parts of Nigeria near livestock pens; it was the most abundant species in the hot Sudan zone, the derived savanna zone, and the Guinea zones and least abundant in the plateau and mangrove zones. Blood-fed females were taken in all zones, with the highest numbers per catch (40.6%) in the forests and 11–36% in other areas; daily peak abundance was from 0100 to 0500 hours with peak numbers of engorged females from 0300 to 0500 hours. Engorged females collected near poultry houses in Nigeria (Dipeolu 1977) were found to be positive for poultry by precipitin testing.

**Distribution.** Ethiopia, Gambia, Kenya, Nigeria, Senegal, South Africa, Tanzania, Uganda, Zimbabwe. It occurs throughout the Afrotropical-Region from South Africa to Senegal and Ethiopia. It is a common and abundant species of the *schultzei* group; probably it has most often been confused in the past with *schultzei*.

**Material Examined.** ETHIOPIA: Kaffa Province, Aposhasa Village, 3-h walk S Genji, 1,150 ft

elev., V. H. Lee, light trap, 18–19-VI-74, 5 ♀♀. GAMBIA: Wet Kiang District, Keneba, D. H. Murphy, reared, 16-XII-59, 4 ♀♀, 2 ♂♂; same data except sticky trap, no date, 1 ♀. KENYA: Nairobi Province, Nairobi, Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey, light trap and CO<sub>2</sub>, 27-V-82, 1 ♀; Rift Valley Province, Marigat, D. Young and R. Beach, light trap, 7–10-VII-81, 3 ♀♀, 1 ♂; Samburu, J. P. Rieb, blacklight trap, 26-I-78, 1 ♂. NIGERIA: Kankiya, B. McMillan, light trap, XII-55, 1 ♂; same data, 12-V-56, 1 ♀; same data, II-57, 2 ♀♀, 2 ♂♂; Ile-Ife, J. T. Medler, VIII-71, 1 ♀. SOUTH AFRICA: Transvaal, Onderstepoort, E. M. Nevill, III-74, 2 ♀♀ (Cornet no. 4087 and 4088), 2 ♂♂ (Cornet no. 4083 and 4084). ZIMBABWE: Ruya Camp, R. J. Phelps, II-70, 1 ♀.

#### *Culicoides* sp. 5

(Fig. 32)

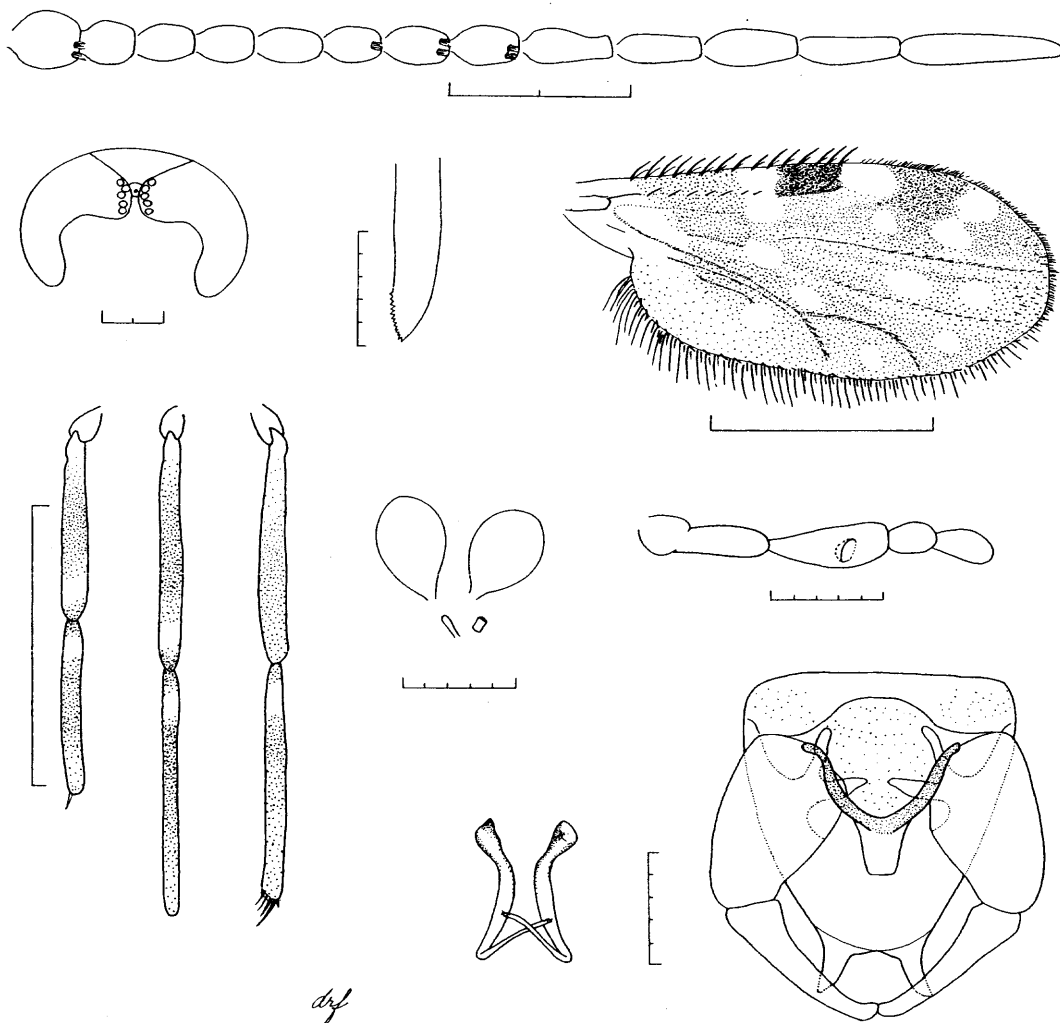
**Diagnosis.** A medium-sized, brownish species. Female eyes moderately separated. Male antennal segment 11 with a short sensillum trichodeum, segments 7 and 9 each with 2 long and 1 short sensilla trichodea. Wing markings very similar to sp. 4; 1 pale spot in distal portion of cell M4, proximal to wing margin; apices of veins dark. **Male Genitalia.** Indistinguishable from that of sp. 4.

**Female.** Wing length 1.00 mm (0.86–1.19 mm,  $n = 4$ ). **Head.** Brown. Eyes moderately separated by a distance equal to the diameter of about 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 23–16–17–18–19–18–19–20–26–25–28–29–48; A.R. 0.99 (0.93–1.04,  $n = 4$ ); sensilla coeloconica (with number per segment) on segments 3(2), 8(1), 9(1–2), 10(2). Third segment of maxillary palpus moderately expanded, with a moderately small, rounded, shallow sensory pit; P.R. 2.58 (2.45–2.65,  $n = 4$ ). Proboscis moderately long, P/H 0.81 (0.74–0.91,  $n = 4$ ); mandible with 13 teeth (11–14,  $n = 4$ ).

**Thorax.** Brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band, fore- and midtibiae broadly paler at apices, hindtibia pale on apical ½; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined mostly to distal ½ of wing, and proximal to margin of anal cell. Wing pattern very similar to that of sp. 4; pale spots in basal ½ of cell M2 and in anal cell more diffuse; a single pale spot in distal portion of cell M4, proximal to wing margin; apices of veins dark. Costal ratio 0.51 (0.49–0.52,  $n = 4$ ).

**Abdomen.** Brown. Spermathecae slightly unequal, ovoid, with very short necks; rudimentary 3rd short and narrow; sclerotized ring moderately long; functional spermathecae 0.046–0.059 by 0.030–0.038 mm and 0.042–0.050 by 0.030 mm ( $n = 3$ ).



**Fig. 32.** *Culicoides* sp. 5 (*schultzei* group). Adult female, male genitalia. (See key for scale.)

**Male. Head.** Antennal segment 11 with a short sensillum trichodeum, segments 7 and 9 each with 2 long and 1 short sensilla trichodea. **Male Genitalia.** Indistinguishable from that of sp. 4.

**Discussion.** *Culicoides* sp. 5 can be distinguished from the other members of the *schultzei* group in Kenya by the single pale spot in cell M4 (proximal to the wing margin) and by the dark apices of the veins. The male genitalia are virtually indistinguishable from those of spp. 4 and 6. The material reported by Boorman & Dipeolu (1979) as *schultzei* group species B may be sp. 5.

**Bionomics.** The immature stages and larval habitat of *Culicoides* sp. 5 are undescribed. *Culicoides* spp. 4 and 5 probably share a similar physiogeographic distribution. Adults of sp. 5 are most likely primarily large mammal feeders based on the low number of antennal sensilla.

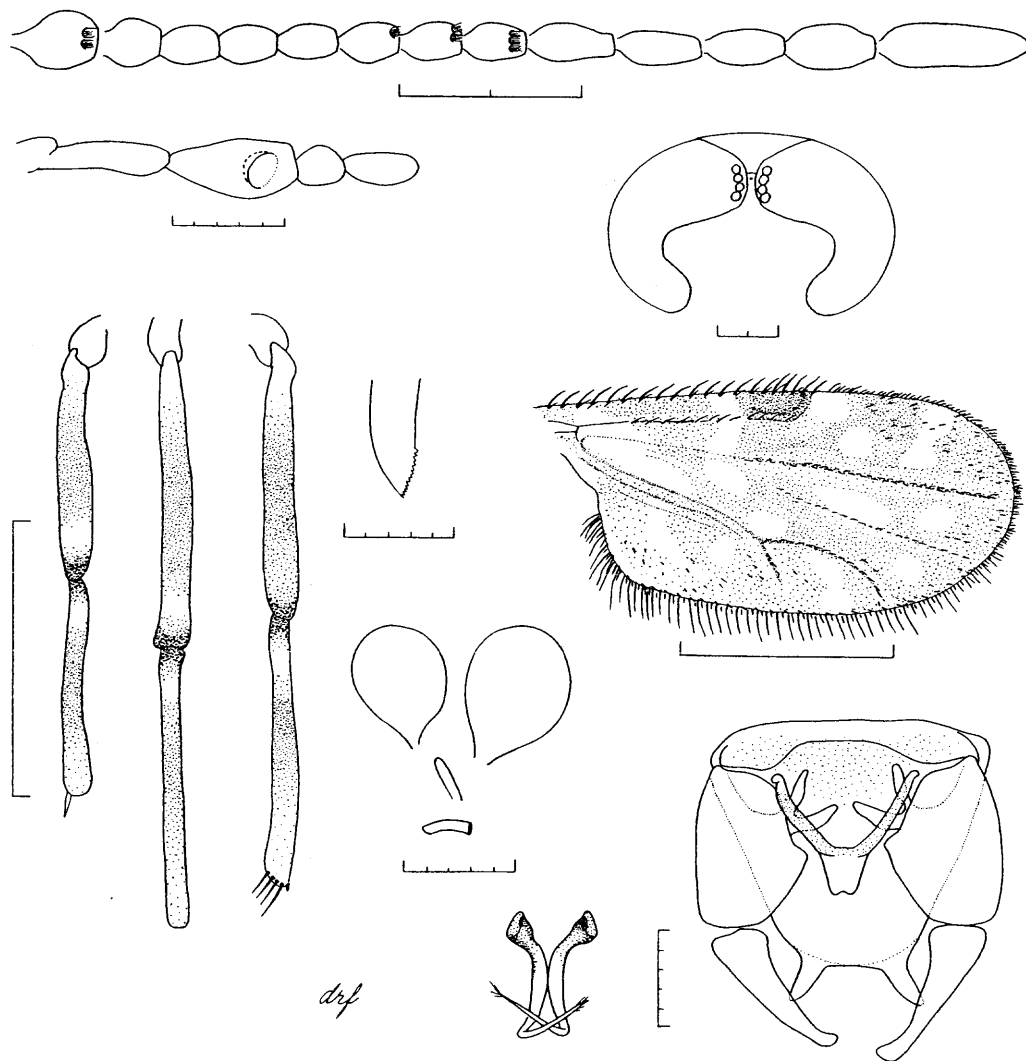
**Distribution.** Kenya, Nigeria, South Africa, Zaire, Zimbabwe. Widely distributed but much less abundant than other species of the *schultzei* group; rare-

ly taken in large numbers (Cornet, personal communication).

**Material Examined.** NIGERIA: Ibadan, V. H. Lee, light trap, 10-11-III-69, 1 ♀; Kankiya, B. McMillan, light trap, II-57, 3 ♂♂. SOUTH AFRICA: Transvaal, Onderstepoort, E. M. Nevill, 8-IX-70, 1 ♀ (Cornet no. 4139), 1 ♂ (Cornet no. 4146). ZAIRE: Gangala, Na Bodio, near Mangava, Baker and Schmitt, 29-IV-55, 1 ♂. ZIMBABWE: Salisbury, E. T. Reid, light trap, 30-V-56, 1 ♀; same data, X-56, 2 ♀♀; same data, VIII-57, 1 ♂.

***Culicoides* sp. 6**  
(Fig. 33)

**Diagnosis.** A medium-sized, brownish species. Female eyes moderately separated. Male antennal segment 11 with a short sensillum trichodeum, segments 7 and 9 each with 1 long and 1 short sensilla trichodea. Wing pattern similar to those of other



**Fig. 33.** *Culicoides* sp. 6 (*schultzei* group). Adult female, male genitalia. (See key for scale.)

members of the group, especially *schultzei*; pale spot in cell M4 transverse, extending from vein M3+4 to wing margin, often with a mesal constriction, entirely divided, or reduced; apices of veins M1, M2, M3+4, and Cul pale. *Male Genitalia*. Indistinguishable from spp. 4 and 5.

**Female.** Wing length 0.96 mm (0.80–1.05 mm,  $n = 4$ ). **Head.** Brown. Eyes moderately separated by a distance equal to the diameter of about 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 24–17–17–17–17–18–19–24–25–24–29–45; A.R. 0.97–1.03 ( $n = 3$ ); sensilla coeloconica (with number per segment) on segments 3(2), 8(1–2), 9(2), 10(2–3). Third segment of maxillary palpus moderately expanded, with a large, rounded, shallow sensory pit; P.R. 2.27 (2.15–2.38,  $n = 4$ ). Proboscis moderately long, P/H 0.74 (0.72–0.78,  $n = 4$ ); mandible with 12–13 teeth ( $n = 4$ ).

**Thorax.** Brown. Legs brown, knees darker; femora pale basally and subapically, indistinct on hindfemur; tibiae each with a subbasal pale band, fore- and midtibiae broadly pale apically, hindtibia pale on apical  $\frac{1}{2}$ ; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

*Wing.* Macrotrichia sparse over distal  $\frac{1}{2}$  of wing and in distal portion of anal cell. Wing pattern similar to those of other members of the group, especially *schultzei*; pale spot in cell M4 transverse, extending from vein M3+4 to wing margin, often with a mesal constriction, entirely divided, or reduced; apices of veins M1, M2, M3+4, and Cul pale. Costal ratio 0.52 (0.50–0.53,  $n = 4$ ).

**Abdomen.** Brown. Spermathecae subequal to slightly unequal, ovoid, with short necks; rudimentary 3rd narrow; sclerotized ring very long (shorter in Ethiopian material); functional spermathecae 0.057 by 0.041 mm (0.051–0.066 by

0.035–0.048 mm,  $n = 4$ ) and 0.054 by 0.039 mm (0.050–0.056 by 0.035–0.041 mm,  $n = 4$ ).

**Male. Head.** Antennal segment 11 with a short sensillum trichodeum, segments 7 and 9 each with 1 long and 1 short sensilla trichodea. **Male Genitalia.** Indistinguishable from spp. 4 and 5.

**Discussion.** *Culicoides* sp. 6 is the most difficult member of the group to identify on the basis of wing pattern because of the variation of the pale marking in cell M4; isolated specimens are particularly difficult and may resemble *kingi*, *schultzei*, or (to some degree) *rhizophorensis*. Adults can be separated from those of *kingi* by the shorter length of the pale spots, especially in cells M1 and M2. Series of specimens of sp. 6 from a specific population are more readily identifiable.

See the discussions of *schultzei* and sp. 4 for further information on the group.

**Distribution.** Ethiopia, Kenya, Senegal, South Africa, Zimbabwe. Widely distributed in all the savanna zones from South Africa to Senegal and Ethiopia but less abundant in West Africa (Cornet, personal communication).

**Material Examined.** ETHIOPIA: Wallo Province, Dupite, Tendaho Cotton Plantation, V. H. Lee, light trap, 24–25-IX-74, 2 ♀♀, 1 ♂. KENYA: Masai Mara, J. P. Rieb, blacklight trap, 1-II-78, 1 ♀. SOUTH AFRICA: Transvaal, "Eenvogelsdrift," Potgietersrus, E. M. Nevill, 14-II-70, 2 ♀♀ (Cornet no. 4107 and 4108), 2 ♂♂ (Cornet no. 4102 and 4103). ZIMBABWE: Kariba, 1,675 ft elev., D. R. Birkenmeyer, blacklight trap, 26-X-67, 1 ♀.

#### *Culicoides similis* Group

**Diagnosis.** Female eyes usually narrowly separated. Female antennal sensory pattern variable, sensilla coeloconica always present on some of the proximal segments and usually absent on distal 5 segments (usually 3–10; 3, 7–10; or 3, 5, 7–10). Third segment of maxillary palpus with a single, often large, distal sensory pit. Hindtibial comb with 4 spines. Wing with distinct pattern of pale spots; spot over r-m crossvein often lying distad of vein at base of cell R5; 2nd radial cell dark to apex; macrotrichia moderately abundant. Female abdomen with 2 functional ovoid spermathecae, the sclerotized necks often long, and a rudimentary 3rd spermatheca; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with moderately short to long apicolateral processes; 9th sternum with caudomedian emargination, the ventral membrane usually not spiculate; dorsal root of basistyle simple, ventral root with anteriorly and posteriorly directed processes; aedeagus usually with deep basal arch, lateral arms often slender, shoulders of arch usually bearing a pair of posteriorly directed, pointed processes; distal median process of aedeagus usually with truncate apex; parameres separate, basal knob stout, stem usually with subapical ventral lobe, distally with a row of lateral fringing spines to apex.

**Kenya Species.** *C. accraensis* Carter, Ingram & Macfie, *C. expectator* Clastrier, *C. karenensis* Glick, n. sp., *C. kobae* Cornet & Chateau, *C. micheli* Cornet & Chateau, *C. papillatus* Khamala & Kettle, *C. parvulus* Khamala & Kettle, *C. preto-riensis* Kremer & Nevill, *C. radiomaculatus* Khamala & Kettle, *C. rarus* De Meillon, *C. similis* Carter, Ingram & Macfie, *C. tropicalis* Kieffer.

#### *Culicoides accraensis* Carter, Ingram & Macfie (Fig. 34)

*Culicoides accraensis* Carter, Ingram & Macfie 1920: 241 (male, female, larva, pupa). Holotype: ♀, cotypes, Gold Coast Colony, Accra, Nsawam (about 25 mi N Accra on Densu River), Oblogo (about 2 mi W Accra on Densu River), and Odorkor (between Accra and Oblogo), all Ghana, A. Ingram and J. W. S. Macfie, reared from larvae in rot holes of flamboyant tree (*Poinciana regia*), silk-cotton trees (*Eriodendron anfractuosum*), cashew trees (*Anacardium occidentale*), and a *Cynometra* sp. (probably *C. megalophylla*), no date (BMNH).

**Diagnosis.** A medium-sized, dark brown species. Female eyes narrowly separated; sensilla coeloconica on antennal segments 3, 7–10; 3rd segment of maxillary palpus moderately to greatly swollen, with a large, deep sensory pit. Wing pattern distinct; pale spot entirely distad of r-m crossvein at base of cell R5; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell, and a pale spot at apex; cell M1 with an elongate pale spot near base, and another spot at apex; pale spot absent over vein M1. **Male Genitalia.** Aedeagus with a pair of posteriorly directed processes from shoulders of basal arch; distal median process of aedeagus long, with truncate apex; paramere with a subapical ventral lobe.

**Female.** Wing length 1.07 mm (0.93–1.16 mm,  $n = 5$ ). **Head.** Dark brown; antenna and palpus lighter brown. Eyes narrowly separated by a distance equal to the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 17–12–12–12–13–13–13–14–20–22–22–23–33; A.R. 1.13 (1.06–1.18,  $n = 5$ ); sensilla coeloconica (with number per segment) on segments 3(1–3), 7(1–2), 8(1–2), 9(1–3), 10(2–4). Third segment of maxillary palpus moderately to greatly expanded, with a large, rounded, deep sensory pit; P.R. 2.12 (1.97–2.30,  $n = 5$ ). Proboscis moderately long, P/H 0.74 (0.68–0.84,  $n = 5$ ); mandible with 13–14 teeth ( $n = 4$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band, less distinct on midfemur; tibiae each with a subbasal pale band, paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia long, moderately abundant in distal portions of cells, especially cell R5. Wing

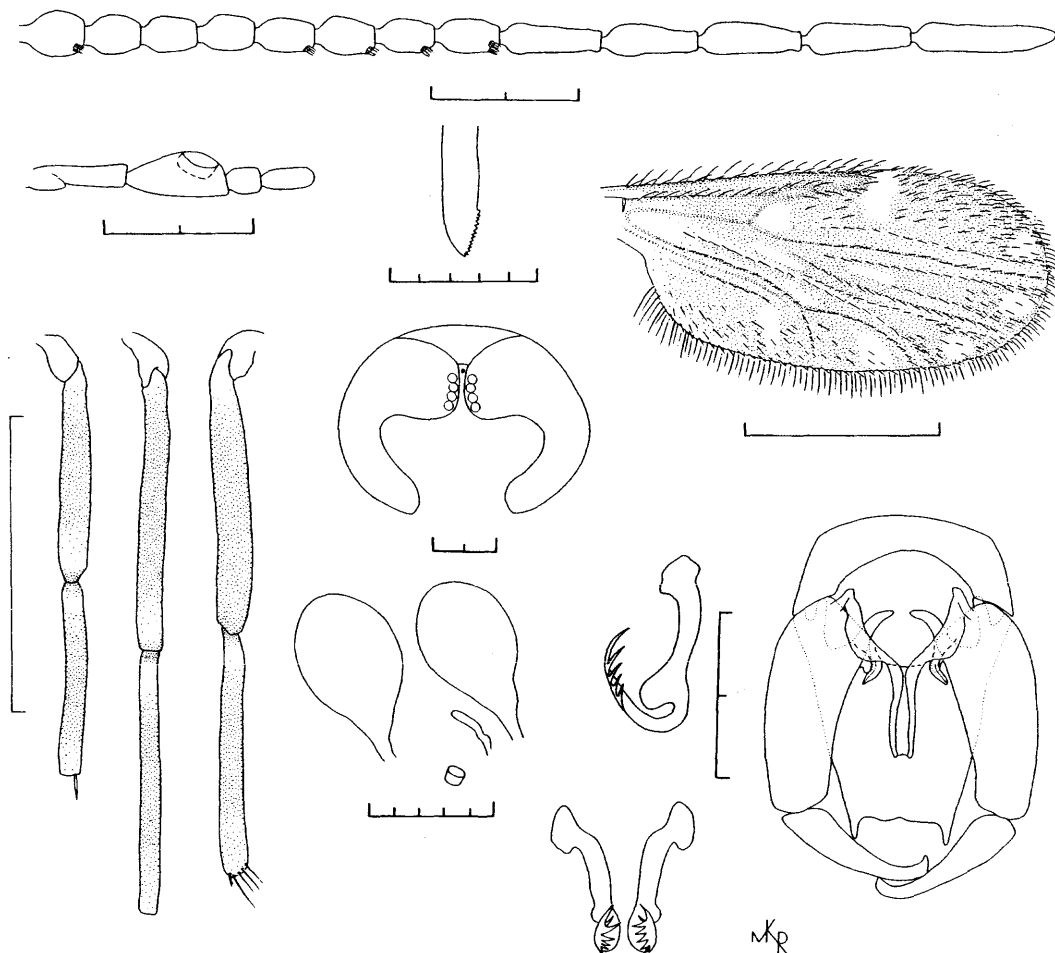


Fig. 34. *Culicoides accraensis* (*similis* group). Adult female, male genitalia. (See key for scale.)

with a small pale spot distad of r-m crossvein, at base of cell R5; cell R5 with a large, transverse pale spot on anterior margin just distad of 2nd radial cell, and a smaller pale spot at apex; cell M1 with an elongate pale spot near base, and a small rounded pale spot at apex; cell M2 with a pale streak at base, a spot just below median fork, a spot just above cubital fork, and a pale spot at apex; cell M4 with a pale spot extending from middle of vein M3+4 to posterior wing margin; anal cell with a diffuse pale area in basal ½ along margin, and a transverse pale spot in distal portion of cell; faint pale streaks present over distal portions of veins M1, M2, and M3+4; wing membrane infuscated grayish brown. Costal ratio 0.57–0.59 ( $n = 5$ ).

**Abdomen.** Dark brown. Spermathecae dark brown, unequal, ovoid, with long sclerotized necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.059 by 0.039 mm (0.055–0.063 by 0.035–0.044 mm,  $n = 5$ ) and 0.046–0.053 by 0.030–0.035 mm ( $n = 2$ ).

**Male Genitalia.** Ninth tergum with tapering sides and moderately long, slender apicolateral process-

es. Ninth sternum with a broad, deep caudomedian emargination; the ventral membrane not spiculate. Dorsal root of basistyle long and stout, ventral root with anteriorly and posteriorly directed processes, anterior process long and stout; dististyle moderately slender distally, nearly straight, with curved, pointed apex. Aedeagus with a broad, deep basal arch, lateral arms expanded distally, shoulders of basal arch with a pair of pointed, posteriorly directed processes; distal median process of aedeagus long, nearly parallel-sided, with truncate apex. Paramere with large basal knob; stem stout, with a large, subapical ventral lobe; distal portion more slender, recurved to a pointed apex, with a row of 5–6 lateral fringing spines, the spines becoming longer towards apex.

**Discussion.** *Culicoides accraensis* can be distinguished from other members of the *similis* group found in Kenya by the following combination of characters: wing with a pale spot just distad of the r-m crossvein, a prominent pale spot near the base of cell M1 and without pale spots over veins M1 and M2, antennal sensory pattern 3, 7–10, and sper-

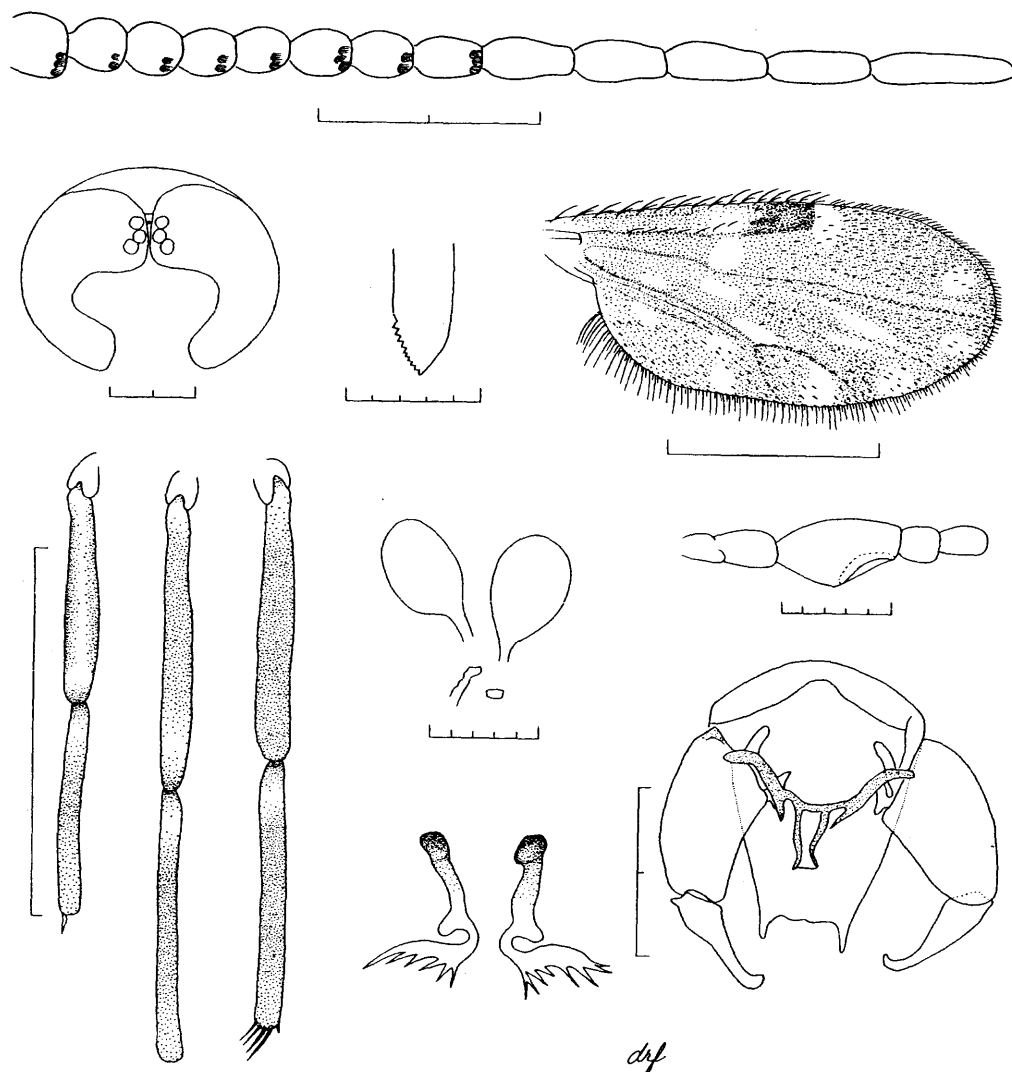


Fig. 35. *Culicoides expectator* (similis group). Adult female, male genitalia. (See key for scale.)

mathecal ring with a wide anterior collar. The male genitalia are most similar to those of *expectator*, *pretoriensis*, and *radiomaculatus*. However, *expectator* has pale streaks above and below vein M2 and is without a pale spot at the base of cell M1; *pretoriensis* has a pale spot directly over the r-m crossvein rather than distal to the vein; and *radiomaculatus* has a pale spot in the basal cell and pale spots over veins M1 and M2, and the paramere does not have a subapical ventral lobe.

Clastrier (1960) compared material previously taken in Algeria under the name of *semimaculatus* Clastrier with *accraensis* collected in the Congo and considered *semimaculatus* to be a synonym of *accraensis*. Callot et al. (1965a) concurred on this synonymy after studying a female collected in Italy under the name of *semimaculatus*, finding variation between it and *accraensis* to be only intraspecific; however, after examining specimens collected in Cameroon (Callot et al. 1965b), they

rehabilitated *semimaculatus* for the Palearctic material, noting differences in the antennal sensilla distribution (3–10 for *semimaculatus*) and the palpal sensory pit of the two in the female, and minor differences in the wing pattern and thoracic coloration of the male.

Khamala & Kettle (1971) noted that their material from East Africa had faint pale spots in the distal third of the wing; however, true *accraensis* has distinct distal pale spots.

Boorman & Dipeolu (1979) referred to their material taken in Nigeria as *accraensis* form A. Emergence records and light trap collections (Dipeolu 1976a,b; Dipeolu & Ogunrinade 1976, 1977) may therefore include material other than true *accraensis*.

**Bionomics.** Carter et al. (1920) described and illustrated the larva and pupa of *C. accraensis*.

*Culicoides accraensis* breeds primarily in tree rot holes, although there are several records of lar-



vae collected from other habitat types. In the Gold Coast (Ghana), Carter et al. (1920), and Macfie & Ingram (1923) reared adults from larvae collected in rot holes of flamboyant trees, cotton trees, cashew trees, and others. De Meillon (1929) reared numerous adults from pupae obtained from tree rot holes in the eastern Transvaal (South Africa). He assumed these to be *accraensis*, although they were not "typical." Braverman (1978) found *accraensis* (as the group) to be the dominant species in rot holes and tree forks in Zimbabwe, associated with species of the *eriodendroni* and *nigripennis* groups. Adults were reared from December to April from a wide variety of trees, including the jacaranda (*Jacaranda mimosifolia* D. Don), msasa (*Brachystegia speciformis* Benth.), Cape fig (*Ficus capensis* Thunb.), mnondo (*Julbernardia globiflora* Benth. Troupin), flame tree (*Spathodea campanulata* Beauv.), erythrina (*Erythrina abyssinica* D.C.), Persian lilac (*Melia azedarach* L.), buffalo thorn (*Zizyphus mucronata* Willd.), cedrela (*Toona ciliata* Roem.), wild fig (*Ficus burkei* (Miq.) Miq.), mulberry (*Morus nigra* L.), and Mount Selinda linden (*Croton sylvaticus* Krauss).

Williams (1966) obtained one adult of *accraensis* from a decomposing cocoa pod collected from the government experimental cocoa plantation in Gambari Forest, Nigeria, during September.

Adults also have been collected from a variety of more aquatic situations. In view of the problems in differentiating members of the *similis* group, the following records may refer to one or more species similar to *accraensis*. In Kenya, Lubega & Khamala (1976) reared adults from mud at the edges of bodies of water such as puddles, pools, lakes, streams, and rivers with or without a vegetative cover and usually frequented by livestock. In Nigeria, Dipeolu & Ogunrinade (1976) found adults emerging from boggy ground of a rocky hill area at Eruwa; and at the University of Ibadan research farm, they (1977), collected adults in low numbers from emergence traps at the margins of a dairy cattle drinking trough, from cattle dung in an open paddock, along the margins of an open drain leading from a slaughterhouse, and from a decomposing grass heap in the vicinity of livestock pens.

In Senegal, Cornet & Chateau (1970) collected *accraensis* adults during the rainy season, noting that this explained their tree hole larval habitat. In East Africa, Khamala (1971) collected adults from savanna (Kenya) and in the Zika Forest (Uganda).

The host-feeding preference of *accraensis* probably is large mammals as predicted by Braverman & Hulley (1979) based on the low number of antennal sensilla. Dipeolu (1976b) made light trap collections near livestock pens from all areas of Nigeria except mangrove swamps. Adults were most numerous in the forest zone; peak abundance and peak numbers of engorged females occurred from 0300 to 0500 hours. At the University of Ibadan research farm (Dipeolu 1976a), adults were collected from various sites around wild animals (these

records may refer to a species other than *accraensis*).

**Distribution.** Cameroon, Congo, Gambia, Ghana, Kenya, Nigeria, Senegal, Uganda, Zimbabwe.

**Material Examined.** GAMBIA: West Kiang District, Keneba, D. H. Murphy, light trap, 5-VII-56, 1 ♀. KENYA: Nairobi Province, Nairobi, Karen, 800 m W Karen Rd., 500 m S Bongani Rd., Noad Farm, 1,850 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 19-XI-81, 1 ♂; Karen, Bowdens property, Karen Rd., 1,850 m elev., C. L. Bailey and Kairo, light trap and CO<sub>2</sub>, 25-V-82, 1 ♀; Kabete, Dr. Davies' garden, C. L. Bailey and Kairo, light trap and CO<sub>2</sub>, 25-V-82, 3 ♀♀; same data, 28-V-82, 2 ♀♀. ZIMBABWE: Kariba, 1,675 ft elev., D. R. Birkenmeyer, blacklight trap, 20-X-67, 1 ♀; Salisbury, E. T. Reid, light trap, IX-56, 1 ♂; same data, 4-XII-56, 1 ♂; same data, I-57, 1 ♀; same data, II-57, 2 ♀♀.

#### *Culicoides expectator* Clastrier (Fig. 35)

*Culicoides expectator* Clastrier 1959: 177 (female). Holotype: ♀, Niokolo-Koba, Senegal, National Park, M. E. Abonnenc, blacklight trap, 1957. Paratypes: 2 ♀♀, same data as holotype (IPA).

**Diagnosis.** A medium-sized, dark brown species. Female eyes narrowly separated, almost contiguous; sensilla coeloconica on antennal segments 3-10; 3rd segment of maxillary palpus greatly expanded, with a large, shallow sensory pit; proboscis short. Wing with pale spot entirely distad of r-m crossvein, at base of cell R5; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell, and a pale spot at apex; without a pale spot over vein M1; cell M1 without a pale spot at base; pale streaks above and below vein M2 at midlength. **Male Genitalia.** Aedeagus with a pair of posteriorly directed processes from shoulders of basal arch; distal median process of aedeagus with truncate apex; paramere with a subapical ventral lobe.

**Female.** Wing length 0.93 mm (0.70-1.06 mm,  $n = 6$ ). **Head.** Dark brown; antenna and palpus lighter brown. Eyes very narrowly separated, almost contiguous; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 16-10-12-12-12-12-13-20-19-21-22-33; A.R. 1.15 (1.06-1.26,  $n = 6$ ); sensilla coeloconica (with number per segment) on segments 3(3), 4(1-2), 5(2), 6(2), 7(2), 8(2-3), 9(2), 10(3). Third segment of maxillary palpus greatly expanded, with a large, shallow sensory pit; P.R. 1.92 (1.67-2.11,  $n = 6$ ). Proboscis short, P/H 0.55 (0.53-0.58,  $n = 6$ ); mandible with 10-11 teeth ( $n = 5$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, forefemur pale subapically and through middle to base, midfemur with a subapical pale band; tibiae each with a subbasal pale band, and paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia abundant over most of wing. Wing with a rounded pale spot just distad of the r-m crossvein at base of cell R5, and pale above to costal margin; cell R5 with a pale spot on anterior margin just distad of the 2nd radial cell, and a spot near apex; cell M1 without a pale spot at base; vein M1 with a moderately distinct pale streak over distal  $\frac{2}{3}$ ; broad pale streaks above and below vein M2 at midlength, forming what appears as a pale spot straddling vein M2, pale streak above vein broader and more distinct; cell M1 with a pale spot at apex; cell M2 with pale spots proximal to Cu vein just before its midlength, just below median fork, just above cubital fork, and at apex; cell M4 with a transverse pale spot extending from vein M3+4 at its midlength to posterior wing margin; anal cell with a pale spot in basal portion, and a double transverse pale spot in distal portion. Costal ratio 0.54 (0.53–0.55,  $n = 6$ ).

**Abdomen.** Dark brown. Spermathecae unequal, ovoid, with long, parallel-sided necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.059 by 0.036 mm (0.048–0.070 by 0.033–0.038 mm,  $n = 4$ ) and 0.056 by 0.032 mm (0.044–0.068 by 0.025–0.037 mm,  $n = 5$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, slender apicolateral processes; caudal margin with a slight mesal emargination. Ninth sternum with a deep caudomedian emargination; ventral membrane not spiculate. Dorsal root of basistyle long and stout, ventral root with prominent anteriorly and posteriorly directed processes, anterior process with pointed apex; dististyle stout basally, distally tapering to a curved, bluntly pointed apex. Aedeagus with a deep basal arch, lateral arms moderately slender; shoulders of aedeagus with a pair of pointed, posteriorly directed processes; distal median process long and stout with truncate apex. Paramere with strong, heavily sclerotized basal knob; stem stout, with a large, subapical ventral lobe; distal portion of stem curving, tapering to a sharply pointed apex, with a row of 5–7 lateral fringing spines to apex.

**Discussion.** The male genitalia of *expectator* is similar to that of *accraensis*; however, the two can be distinguished by wing pattern.

Cornet & Chateau's (1970) description of the aedeagus does not agree with specimens of *expectator* from Senegal and Zimbabwe in the USNM; the male (No. 380, Senegal; specified as the allotype) has no standing because it was not part of the original type series designated by Clastrier (1959).

The male described by Callot et al. from Angola (in Cornet & Chateau 1970) as *expectator* may actually be *C. tropicalis* Kieffer. Cornet (personal communication) suggests *expectator* may be a complex of several species that are difficult to distinguish.

**Bionomics.** The immature stages of *Culicoides expectator* are undescribed.

Lubega & Khamala (1976) reared adults in Ken-

ya at Lake Nakuru from water-logged mud from freshwater marshes overgrown with *Cyperus* and *Typha* and from mud taken at the edges of various other bodies of water.

In Nigeria, Dipeolu & Ogunrinade (1976) collected adults from boggy ground of a rocky hill site at Eruwa. At the University of Ibadan research farm, *expectator* was most numerous from emergence traps placed at the margins of a dairy cattle drinking trough and from the margins of an open drain leading from a slaughterhouse; one adult also was collected from an emergence trap placed over cattle dung in an open paddock.

Khamala (1971) collected *expectator* in Kenya from savanna areas, and Walker (1976) collected adults from moist *Combretum* woodland and grassland and arid *Acacia-Commiphora* bushland. In West Africa, Dipeolu (1976b) collected *expectator* from near livestock pens in low to moderate numbers from all areas of Nigeria except mangrove swamp; it was most numerous in forests, with the peak abundance of engorged females occurring from 2100 to 2300 hours. At the University of Ibadan research farm, adults were collected from various sites near wild animals (Dipeolu 1977).

Braverman & Hulley (1979) predicted the host preference of *expectator* to be larger mammals based on the low number of antennal sensilla; however, with sensilla on eight antennal segments, it is more likely that *expectator* may have a preference for smaller mammals.

**Distribution.** Angola, Gambia, Kenya, Mali, Nigeria, Senegal, Upper Volta, Zimbabwe.

**Material Examined.** GAMBIA: West Kiang District, Keneba, D. H. Murphy, at light, 20-XI-59, 1 ♀. NIGERIA: Kankiya, B. McMillan, light trap, 1956, 1 ♀. SENEGAL: Saboya (Nioro du Rip), light trap, 22-IV-71, 1 ♂. ZIMBABWE: Salisbury, E. T. Reid, light trap, X-56, 3 ♀♀; same data, VIII-57, 1 ♀, 1 ♂.

#### *Culicoides karenensis* Glick, new species (Fig. 36)

**Diagnosis.** A medium-sized, brownish species, somewhat similar to *accraensis*. Female eyes narrowly separated; sensilla coeloconica on antennal segments 3, 7–10; 3rd segment of maxillary palpus short and broad, with a large, moderately shallow sensory pit; proboscis short. Wing with pale spots somewhat reduced, especially in cell M2; cell M1 without a prominent pale spot near base, with only a faint indication of a narrow pale streak present. Female abdomen with functional spermathecae unequal, ovoid, with long necks; sclerotized ring with a wide anterior collar. Male unknown.

**Female.** Wing length 1.02 mm (0.94–1.12 mm,  $n = 21$ ). **Head.** Brown. Eyes narrowly separated by a distance equal to the diameter of about  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 17–11–11–12–12–13–13–14–24–26–26–27–38; A.R.

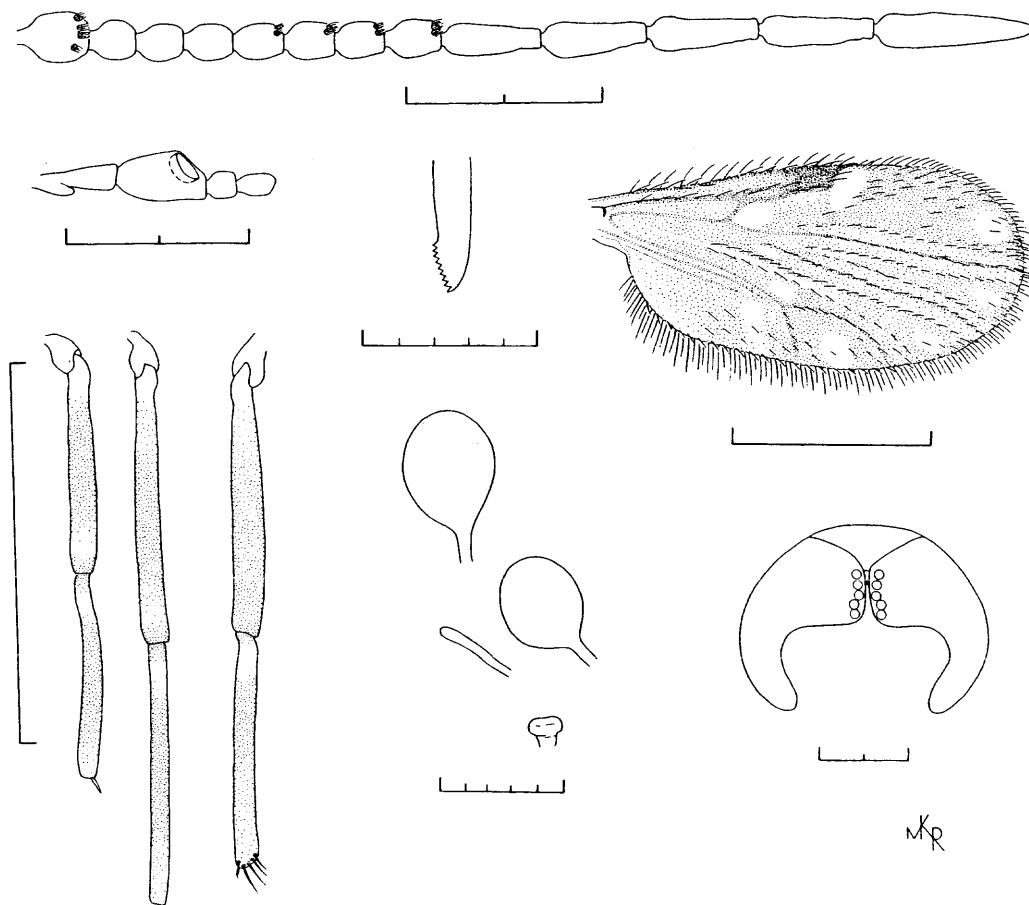


Fig. 36. *Culicoides karenensis*, n. sp. (*similis* group). Adult female. (See key for scale.)

1.38 (1.31–1.44,  $n = 12$ ); sensilla coeloconica (with number per segment) on segments 3(2–4), 7(1–3), 8(2–3), 9(2–3), 10(2–4). Third segment of maxillary palpus short and broad, with a large, rounded, moderately shallow sensory pit; P.R. 1.76 (1.66–1.87,  $n = 21$ ). Proboscis short, P/H 0.57 (0.52–0.62,  $n = 21$ ); mandible with 9–10 teeth ( $n = 21$ ).

**Thorax.** Brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band, apices faintly paler; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined mostly to distal  $\frac{1}{2}$  of wing, and near posterior wing margin. Wing pattern similar to that of *accraensis*, pale spots somewhat reduced; wing with a small, rounded pale spot just distad of the r-m crossvein at base of cell R5; cell R5 with a transverse pale spot on anterior margin just distad of 2nd radial cell, and a rounded pale spot at apex of cell; cell M1 with only a faint, narrow pale streak near base, and a pale spot at apex; cell M2 with small pale spots below median fork, above cubital fork, and at apex; cell M4 with a pale spot proximal to posterior wing

margin; anal cell with a diffuse pale area in basal portion proximal to posterior wing margin, and a transverse pale spot in distal portion. Costal ratio 0.55 (0.53–0.56,  $n = 21$ ).

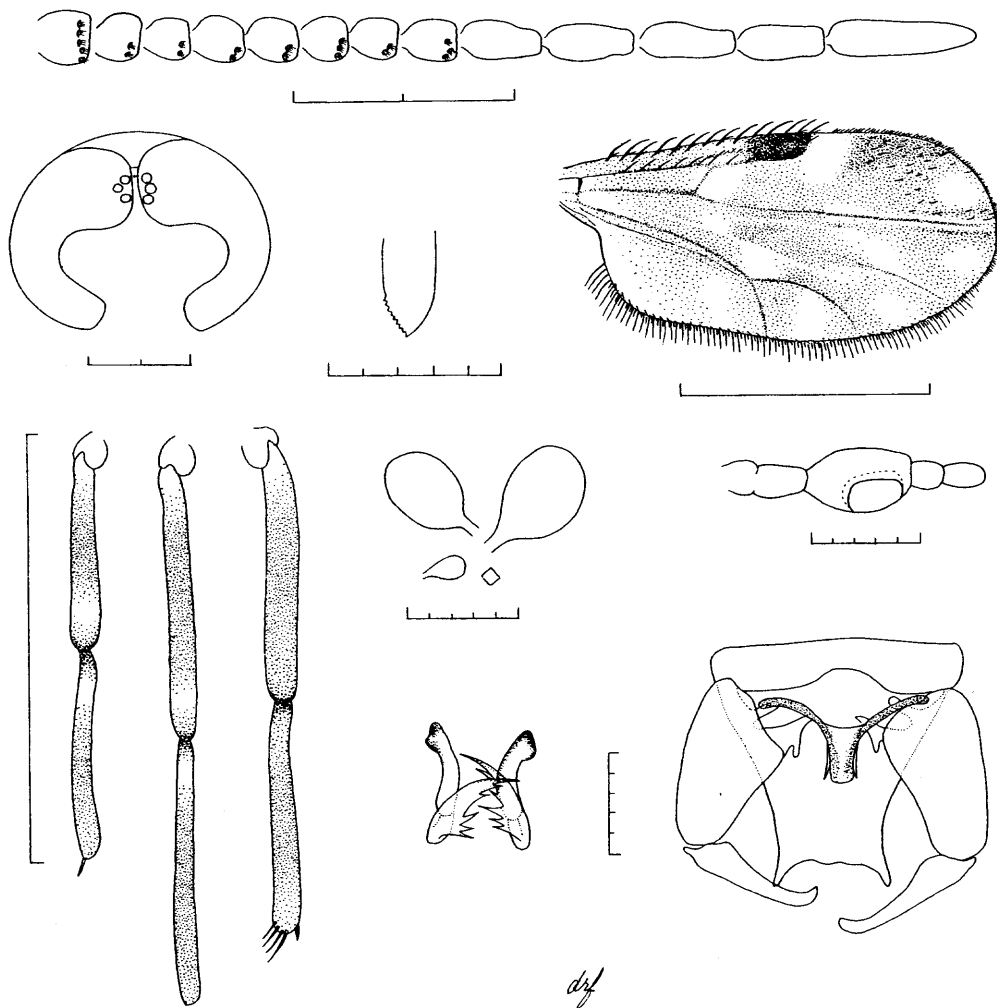
**Abdomen.** Brown. Spermathecae brown, unequal, ovoid, with long, parallel-sided necks; rudimentary 3rd relatively long and slender; sclerotized ring with a wide anterior collar; functional spermathecae 0.052 by 0.038 mm (0.048–0.059 by 0.033–0.046 mm,  $n = 14$ ) and 0.043 by 0.031 mm (0.038–0.048 by 0.024–0.035 mm,  $n = 15$ ).

**Male.** Unknown.

**Etymology.** The specific name is derived from the type locality.

**Discussion.** *Culicoides karenensis* n. sp. is somewhat similar to *accraensis* but can be distinguished by the absence of a distinct pale spot at the base of cell M1, the greater antennal ratio, the shallower palpal sensory pit, and the shorter proboscis with fewer mandibular teeth.

**Bionomics.** The immature stages and larval habitat of *Culicoides karenensis* are undescribed. The host preference of *karenensis* is probably larger mammals based on its low number of antennal sensilla.



**Fig. 37.** *Culicoides kobae* (*similis* group). Adult female, male genitalia. (See key for scale.)

**Distribution.** Kenya.

**Type Material.** HOLOTYPE: ♀, Nairobi Province, Nairobi, Kenya, Karen, 800 m W Karen Rd., 1,000 m S Bongani Rd., N fork of Mbagathi River, Noad Farm, lower stream forest, 1,650 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 11-XII-81 (USNM Type No. 100685). PARATYPES: 4 ♀♀, same data as holotype; the following specimens same data as holotype except: 2 ♀♀, 17-XI-81; 1 ♀, 4-XII-81; 1 ♀, 5-XII-81; 6 ♀♀, 8-XII-81; 5 ♀♀, 10-XII-81. Holotype and 11 paratypes, USNM; 2 paratypes, BMNH; 2 paratypes, ORSB; 1 paratype, MHNP; 1 paratype, IPS; 2 paratypes, NMK.

***Culicoides kobae* Cornet & Chateau**

(Fig. 37)

*Culicoides kobae* Cornet & Chateau 1970: 148 (male, female). Holotype: ♂ no. 1087, Niokolo-Koba National Park, Senegal, M. Cornet and R. Chateau, light trap, 22-V-69. Allotype: ♀ no. 855,

same data as holotype. Paratypes: 10 ♀♀, 10 ♂♂, in alcohol, same data as holotype (ORSB).

**Diagnosis.** A small, dark brown species. Female eyes narrowly separated; sensilla coeloconica on antennal segments 3–10; 3rd segment of maxillary palpus greatly expanded, with a large, shallow sensory pit; proboscis short. Wing with large pale spot almost entirely distad of r-m crossvein; cell M1 with a broad, elongate pale spot at middle, proximal to vein M2; moderately prominent pale streaks over distal portion of veins M1 and M2. *Male Genitalia.* Ninth tergum with long, slender apicolateral processes; aedeagus without pair of posteriorly directed processes from shoulders of basal arch; sides of distal median process of aedeagus with a pair of long, slender pointed processes; stem of paramere with a large subapical ventral lobe.

**Female.** Wing length 0.84 mm (0.81–0.92 mm,  $n = 10$ ). **Head.** Dark brown. Eyes narrowly separated by a distance equal to the diameter of about

$\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 16-9-9-10-10-10-10-11-16-18-19-18-30; A.R. 1.21 (1.10-1.32,  $n = 7$ ); sensilla coeloconica (with number per segment) on segments 3(2-6), 4(1-2), 5(1-3), 6(1-3), 7(1-3), 8(2-4), 9(2-3), 10(2-4). Third segment of maxillary palpus greatly expanded, with a large, rounded, shallow sensory pit; P.R. 1.82 (1.73-1.92,  $n = 10$ ). Proboscis short, P/H 0.53 (0.48-0.56,  $n = 10$ ); mandible with 9 teeth (8-10,  $n = 10$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a sub-basal pale band, apices paler; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined mostly to distal portion of cells. Wing with a large pale spot over r-m crossvein extending to costal margin, pale spot mostly distad of r-m crossvein; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell, and a pale spot at apex; area below radial cells somewhat paler; pale streaks over distal portions of veins M1 and M2; cell M1 with a broad, elongate pale spot at midlength, proximal to vein M2, coalescing with pale streak over vein M2, and a pale spot at apex of cell; cell M2 pale basally, with moderately distinct pale spots below median fork and above cubital fork, an indistinct pale area proximal to vein M2 at its midlength, and a pale spot at apex of cell; cell M4 with a large transverse pale spot extending from vein M3+4 to posterior wing margin; anal cell extensively pale in basal  $\frac{1}{2}$ , and with a large transverse pale spot in distal portion of cell, with a slight mesal constriction. Costal ratio 0.54 (0.52-0.56,  $n = 10$ ).

**Abdomen.** Dark brown. Spermathecae dark brown, unequal, ovoid, with long, parallel-sided necks; rudimentary 3rd and sclerotized ring short; functional spermathecae 0.058 by 0.036 mm (0.052-0.062 by 0.035-0.038 mm,  $n = 10$ ) and 0.048 by 0.030 mm (0.041-0.053 by 0.029-0.033 mm,  $n = 10$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, slender apicolateral processes. Ninth sternum with a broad, moderately deep caudomedian emargination; the ventral membrane not spiculate. Basistyle tapering distally; dorsal root long and moderately stout with truncate apex, ventral root with anteriorly and posteriorly directed processes; dististyle tapering, distal portion curving to a pointed apex. Aedeagus with a broad, moderately deep basal arch; lateral arms slender, heavily sclerotized; aedeagus without a pair of posteriorly directed processes from shoulders of basal arch; distal median process short and broad with truncate apex, sides with a pair of long, slender, sharply pointed processes. Paramere with stout basal knob; main stem stout, with a large subapical ventral lobe; stem narrowing to a slender, recurved process with pointed apex and about 5 laterally fringing spines.

**Discussion.** *Culicoides kobae* is most similar to

*pretoriensis* Kremer & Nevill but can be distinguished by the prominent pale streaks over the distal portions of veins M1 and M2; the more distinct distal pale spots in cells R5, M1, and M2 (extending to the wing margin); the shorter proximal antennal segments; and the shorter, more expanded third palpal segment.

**Bionomics.** The immature stages, larval habitat, and adult feeding preferences of *Culicoides kobae* are undescribed. Because *kobae* has a high number of antennal sensilla, it may have a preference for smaller animals.

**Distribution.** Kenya, Nigeria, Senegal, Upper Volta, Zimbabwe.

**Material Examined.** NIGERIA: Vom, J. Boorman, at light, 22-I-75, 1 ♂; same data except W. Taylor, 5-III-75, 1 ♂. ZIMBABWE: Kariba, 1,675 ft elev., D. R. Birkenmeyer, blacklight trap, 20-X-67, 3 ♀♀; same data, 26-X-67, 1 ♀; same data, 25-XI-67, 2 ♀♀; same data, 6-II-68, 3 ♀♀; same data, 6-X-68, 1 ♀.

#### *Culicoides micheli* Cornet & Chateau (Fig. 38)

*Culicoides micheli* Cornet & Chateau 1970: 164 (male, female). Holotype: ♂ no. 1080, Niokolo-Koba National Park, Senegal, M. Cornet and R. Chateau, light trap, 22-V-69. Allotype: ♀ no. 1081, same data as holotype. Paratypes: 4 ♀♀, 4 ♂♂, in alcohol, same data as holotype (ORSB).

**Diagnosis.** A moderately small, brownish species. Female eyes moderately separated; sensilla coeloconica on antennal segments 3, 7-10. Wing without prominent pattern; with only a narrow pale area proximal to the radial cells, and indistinct pale spots in cell M4 and anal cell. **Male Genitalia.** Ninth tergum with long, slender apicolateral processes; basistyle with anterior process of ventral root very long; shoulders of aedeagus without a pair of posteriorly directed processes; sides of distal median process of aedeagus with a pair of long, slender, pointed processes; stem of paramere with a sub-apical ventral lobe.

**Female.** Wing length 0.89 mm (0.78-1.04 mm,  $n = 4$ ). **Head.** Dark brown; antenna and palpus lighter brown. Eyes moderately separated by a distance equal to the diameter of 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 14-9-9-10-10-11-11-13-18-19-20-19-25; A.R. 1.14-1.19 ( $n = 3$ ); sensilla coeloconica (with number per segment) on segments 3(3), 7(1), 8(1-2), 9(1-2), 10(2). Third segment of maxillary palpus moderately expanded, with a moderately large, rounded, shallow sensory pit; P.R. 2.17 (2.06-2.22,  $n = 4$ ). Proboscis moderately short, P/H 0.76 (0.74-0.78,  $n = 4$ ); mandible with 12 teeth ( $n = 3$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, fore- and midfemora paler

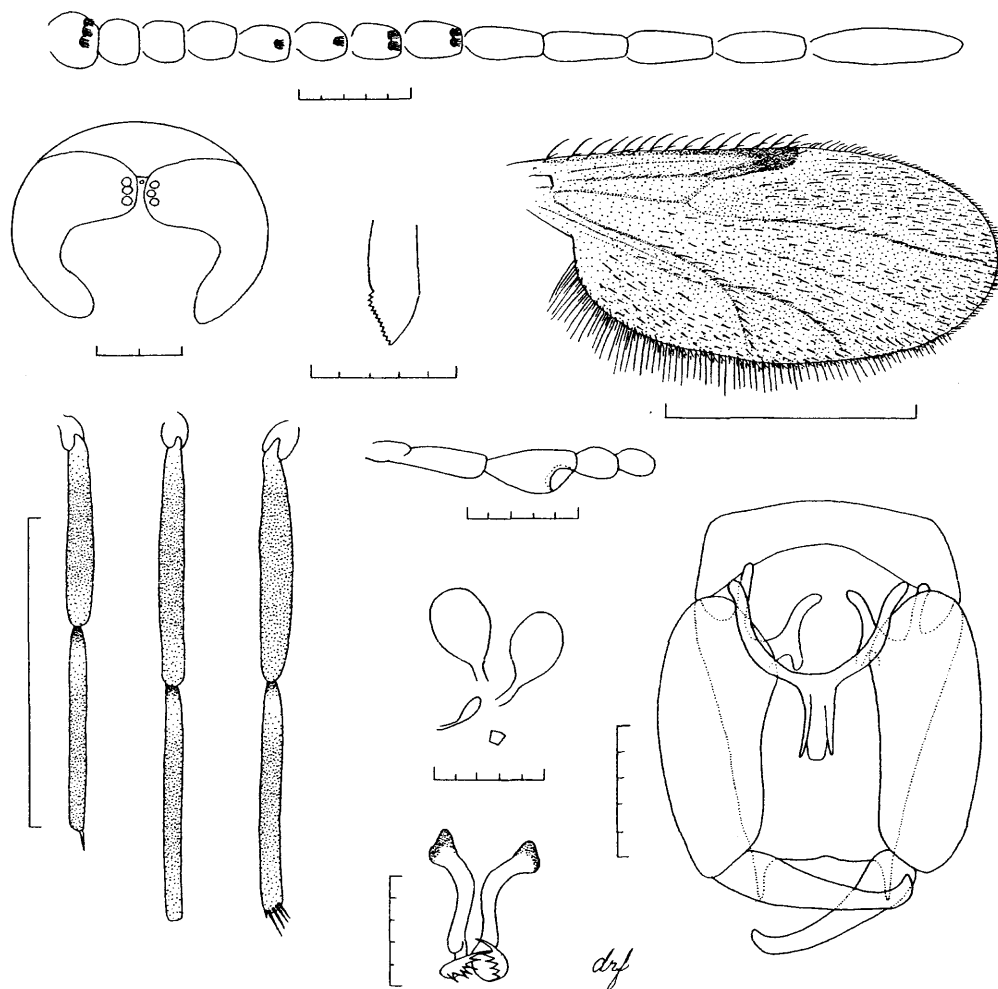


Fig. 38. *Culicoides micheli* (similis group). Adult female, male genitalia. (See key for scale.)

apically; tibiae each with a subbasal pale band, paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter infuscated brown.

**Wing.** Macrotrichia abundant over entire wing except in basal portion. Wing membrane infuscated grayish brown, veins and macrotrichia darker brown. Wing without a prominent pattern; with only a narrow pale area proximal to the radial cells, extending from just distad of the r-m crossvein to the apex of the costa; indistinct pale spots in distal portions of cell M4 and anal cell. Costal ratio 0.54 (0.53–0.55,  $n = 4$ ).

**Abdomen.** Brown. Spermathecae pale brown, slightly unequal, ovoid, with long, parallel-sided sclerotized necks; rudimentary 3rd and sclerotized ring short; functional spermathecae 0.046–0.048 by 0.028–0.029 mm ( $n = 3$ ) and 0.041 by 0.024–0.025 mm ( $n = 2$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, slender apicolateral processes; caudal margin with a very small mesal emargination. Ninth sternum with a broad, deep caudomedian emar-

gination; the ventral membrane not spiculate. Basistyle elongate, slightly tapering distally; dorsal root long and moderately stout, ventral root with prominent anteriorly and posteriorly directed processes, anterior process very long; dististyle nearly straight, tapering distally, apex curved, with pointed tip. Aedeagus with a broad, deep basal arch; lateral arms moderately slender, bases slightly curved anterolaterally; shoulders of aedeagus without a pair of posteriorly directed processes; distal median process of aedeagus long and moderately stout with truncate apex, sides with a pair of long, slender, pointed processes. Paramere with stout basal knob; stem moderately stout, with subapical ventral lobe; distally recurved to a slender, pointed apex, with about 5 lateral fringing spines.

**Discussion.** Among the *similis* group species in Kenya, *micheli* is most similar to *ravus* but can be distinguished by the indistinct pale spots in cell M4 and the anal cell, the greater eye separation, and the antennal sensory pattern of 3, 7–10 rather than 3–10.

**Bionomics.** The immature stages, larval habitat, and adult feeding habits of *micheli* are undescribed.

**Distribution.** Kenya, Senegal, South Africa, Zimbabwe.

**Material Examined.** KENYA: Nairobi Province, Nairobi, Karen, 800 m W Karen Rd., 1,000 m S Bongani Rd., N fork Mbagathi River, Noad Farm, lower stream forest, 1,650 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 4-XII-81, 1 ♂; same data, 5-XII-81, 1 ♀. SOUTH AFRICA: Natal, Ndumu Reserve, at light, 14-V-71, 1 ♂; same data, 15-V-71, 1 ♀. ZIMBABWE: Zimbare, Magondi Reserve, P. Gaddie, III-70, 2 ♀♀.

***Culicoides papillatus* Khamala & Kettle**

(Fig. 53, right)

*Culicoides papillatus* Khamala & Kettle 1971: 84 (male). Holotype: ♂, Kaimosi, Kenya, C. Khamala, light trap, 24-XI-66 (BMNH).

**Diagnosis.** A medium-sized, brownish species. Wing with pale spot almost entirely distad of r-m crossvein at base of cell R5; cell M1 with a faint pale streak near base. **Male Genitalia.** Ninth tergum with short, stout apicolateral processes; shoulders of aedeagus without a pair of posteriorly directed processes; distal median process of aedeagus moderately long, stout, apex truncate, with minute papillae along caudal margin; paramere with large subapical ventral lobe. Female unknown.

**Male** (described from holotype). Wing length 0.90 mm. Head, thorax, and abdomen brown; mesonotum without discernable pattern. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a prominent subbasal pale band, paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia very sparse, most conspicuous near wing margin, confined almost entirely to veins, distal ½ of cell R5, and distal portion of cell M1, with a few at apex of cell M2. Wing with a small pale spot almost entirely distad of r-m crossvein at base of cell R5, not extending to costal margin; cell R5 with a large, transverse pale spot on anterior margin just distad of 2nd radial cell, and a pale spot at apex; cell M1 with a faint pale streak near base, and a pale spot at apex; cell M2 with a diffuse pale streak in basal portion, coalescing with a moderately distinct pale area below median fork, a small, weak pale area proximal to cubital fork, and a pale spot at apex; cell M4 with a moderately large pale spot in distal portion, extending from vein M3+4 to posterior wing margin; basal portion of anal cell pale to posterior margin, and with a pale spot in distal portion of cell; somewhat weak pale streaks over distal ¾ of vein M1 and distal ½ of vein M2.

**Male Genitalia.** Ninth tergum with tapering sides and moderately short, stout apicolateral processes;

the caudal margin with a small mesal emargination. Ninth sternum with a broad, moderately shallow caudomedian emargination; the ventral membrane not spiculate. Basistyle elongate, distally tapering; dorsal root long and stout with truncate apex, ventral root with prominent anteriorly and posteriorly directed processes, anterior process very large and stout, curving anterolaterally, with pointed apex; dististyle nearly straight, tapering distally, apex curved with pointed tip. Aedeagus with a broad, deep basal arch, lateral arms slender with slightly sinuate bases; shoulders of aedeagus without a pair of posteriorly directed processes; distal median process of aedeagus moderately long, stout, slightly tapering to a truncate apex, with minute papillae along caudal margin. Paramere with large, anterolaterally directed basal knob; stem stout, nearly straight, with a large subapical ventral lobe; distal portion recurved to a slender, sharply pointed apex with 7 lateral fringing spines, the proximal 4 shorter and closely approximated, the distal 3 longer and more widely spaced to apex.

**Discussion.** *Culicoides papillatus* is known only from the male holotype. The minute papillae along the caudal margin of the distal median process of the aedeagus will help differentiate this species from all other males of the *similis* group.

**Bionomics.** The immatures and larval habitat of *papillatus* are unknown. The male holotype was collected by light trap in November.

**Distribution.** Kenya.

**Material Examined.** KENYA: Kaimosi, C. Khamala, light trap, 24-XI-66, ♂ holotype.

***Culicoides parvulus* Khamala & Kettle**

(Fig. 39)

*Culicoides parvulus* Khamala & Kettle 1971: 62 (female). Holotype: ♀, Kaimosi, Kenya, C. Khamala, light trap, 15-X-66 (BMNH).

**Diagnosis.** A medium-sized, dark brown species. Female eyes very narrowly separated; sensilla coeloconica on antennal segments 3, 10, 12, 14; third segment of maxillary palpus greatly expanded, with a large, deep sensory pit opening by a smaller pore; proboscis short. Wing with moderately distinct pale spots just distad of r-m crossvein, on anterior margin just distad of 2nd radial cell, and in distal portions of cell M4 and anal cell. Female abdomen with functional spermathecae subequal; sclerotized ring moderately long. Male unknown.

**Female** (described from holotype). Wing length 0.95 mm. **Head.** Dark brown. Eyes very narrowly separated by a distance less than the diameter of ½ an ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 34-26-26-26-28-26-27-30-40-39-39-42-60; A.R. 0.99; sensilla coeloconica (with number per segment) on segments 3(3), 10(1), 12(2), 14(4). Third segment of maxillary palpus greatly expanded, with a large, deep sensory pit, opening by a smaller pore;

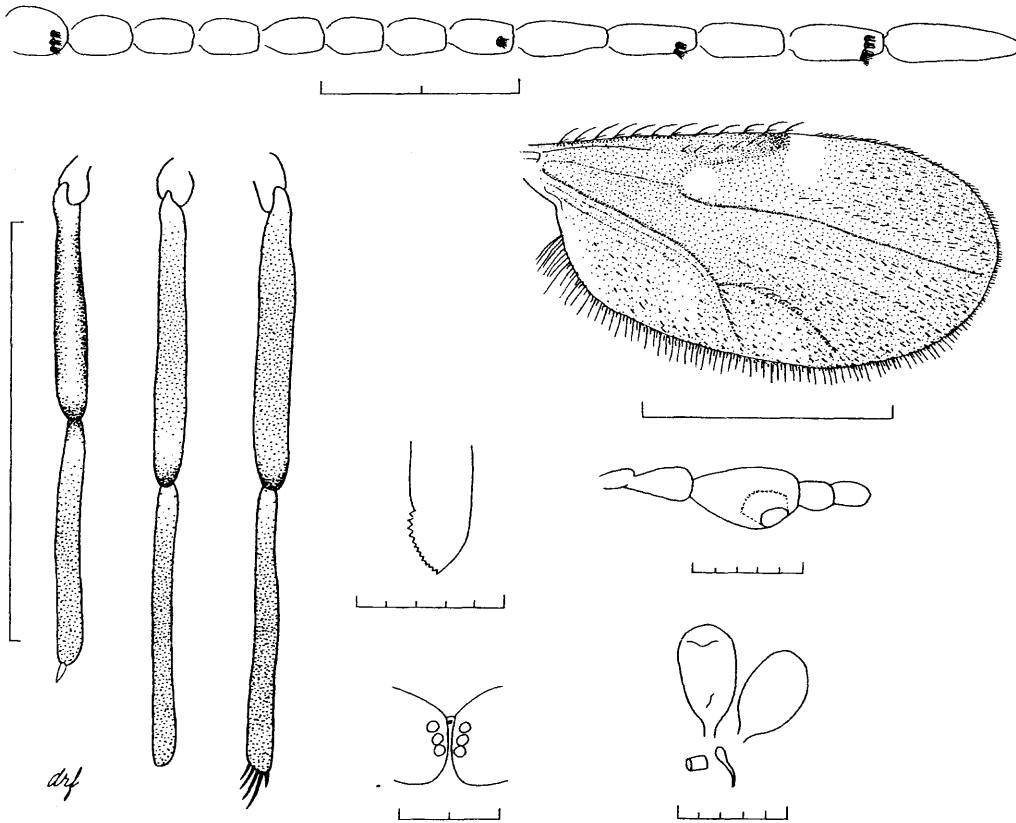


Fig. 39. *Culicoides parvulus* (*similis* group). Adult female. (See key for scale.)

P.R. 1.77. Proboscis short, P/H 0.56; mandible with 13 teeth.

**Thorax.** Dark brown. Legs brown; femora pale basally, forefemur pale subapically and through middle to base, midfemur pale subapically; foretibia with a subbasal pale band, mid- and hindtibiae pale basally; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia abundant over distal  $\frac{1}{2}$  of wing and anal cell. Membrane infuscated pale grayish brown, costa and radial veins darker. Wing pattern reduced, with a small, rounded pale spot just distad of the r-m crossvein at base of cell R5; a moderately large, transverse pale spot on anterior margin just distad of 2nd radial cell; and moderately distinct pale spots in distal portions of cell M4 and anal cell; base of cell M1 and middle of cell M2 slightly paler. Costal ratio 0.54.

**Abdomen.** Brown. Spermathecae subequal, ovoid, with moderately long, parallel-sided, sclerotized necks; rudimentary 3rd narrow; sclerotized ring moderately long; functional spermathecae 0.052 by 0.028 and 0.051 by 0.025 mm.

**Male.** Unknown.

**Discussion.** *Culicoides parvulus* is known only from the female holotype. The reduced wing pattern, unusual antennal sensory pattern, and greatly expanded third palpal segment with a deep sensory

pit enables *parvulus* to be easily differentiated from other members of the *similis* group in Kenya.

Khamala & Kettle (1971) placed *parvulus* in the *stercorarius* group on the basis of the ill-defined pale spots on the wing and the distribution of macrotrichia. However, Cornet (personal communication) notes that this species apparently is a member of the *similis* group, a conclusion which appears correct based on the position of the pale spot distad of the r-m crossvein and the antennal sensory pattern.

**Bionomics.** The immature stages and larval habitat of *Culicoides parvulus* are undescribed. The female holotype was collected by light trap in mid-October. Braverman & Hulley (1979) predicted the host preference of *parvulus* to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Kenya.

**Material Examined.** KENYA: Kaimosi, C. Khamala, light trap, 15-X-66, ♀ holotype.

*Culicoides pretoriensis* Kremer & Nevill  
(Fig. 40)

*Culicoides pretoriensis* Kremer & Nevill 1972: 464 (male). Paratypes: 1 ♂, Onderstepoort, South Africa, E. M. Nevill, light trap, 2-III-66; 3 ♂♂, same



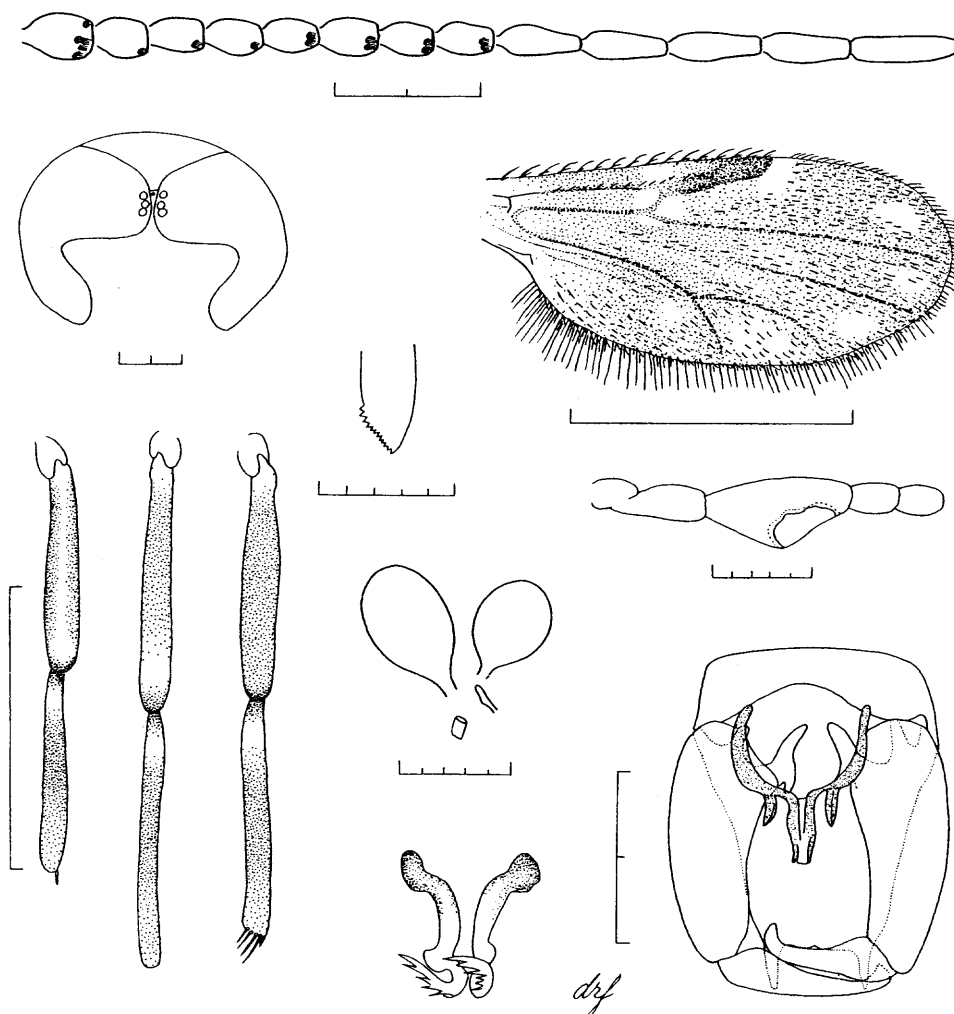


Fig. 40. *Culicoides pretoriensis* (similis group). Adult female, male genitalia. (See key for scale.)

data, 7-XI-66; 1 ♂, same data, 21-XI-66; 4 ♂♂, same data, 4-XII-69; 1 ♂, Windhoek, E. M. Nevill, light trap, 19-III-70; 3 ♂♂, same data, 1-XII-70; 1 ♂, Okahandja, E. M. Nevill, light trap, 1-I-71; 1 ♂, Gobabis, E. M. Nevill, light trap, 26-XI-70; 1 ♂, Letaba Camp, E. M. Nevill, light trap, 1-I-71 (IPS, VRIO).

**Diagnosis.** A medium-sized, dark brown species. Female eyes very narrowly separated; sensilla coeloconica on antennal segments 3–10; 3rd segment of maxillary palpus moderately expanded, with a large, shallow sensory pit. Wing with a moderately distinct pattern of pale spots; a large spot over r-m crossvein extending anteriorly to costal margin; a pale spot on anterior margin just distad of 2nd radial cell; pale spots in distal portions of cells R5, M1, M2, M4, and anal cell. Female abdomen with spermathecae unequal. **Male Genitalia.** Ninth tergum with long, slender apicolateral processes; ventral root of basistyle very large; shoulders of ae-

deagus with a pair of posteriorly directed processes; stem of paramere with subapical ventral lobe.

**Female.** Wing length 0.83–1.03 mm ( $n = 3$ ). **Head.** Dark brown. Eyes very narrowly separated by a distance less than the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 21–16–16–17–16–17–17–17–24–25–28–27–34; A.R. 0.93–1.00 ( $n = 3$ ); sensilla coeloconica (with number per segment) on segments 3(2–5), 4(1), 5(1–2), 6(1–2), 7(1–2), 8(1–2), 9(1–2), 10(1–3). Third segment of maxillary palpus moderately expanded, with a large, shallow sensory pit; P.R. 2.23–2.32 ( $n = 3$ ). Proboscis moderately short, P/H 0.65–0.67 ( $n = 3$ ); mandible with 10–12 teeth ( $n = 3$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, forefemur pale subapically and through middle to base, midfemur with a moderately distinct subapical pale band; tibiae each with a subbasal pale band and paler apically; hind-tibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia abundant over most of wing, except near base. Wing pattern moderately distinct; a prominent, large pale spot over r-m crossvein extending anteriorly to costal margin; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell, and a pale spot near apex; cell M1 with an indistinct pale area near base, and a pale spot near apex; cell M2 pale basally and at mid-length, and with a pale spot near apex; cell M4 with a large pale spot filling most of cell; anal cell pale basally, and with an indistinct pale spot in distal portion. Costal ratio 0.57–0.59 ( $n = 3$ ).

**Abdomen.** Dark brown. Spermathecae unequal, ovoid, with moderately long, parallel-sided sclerotized necks; rudimentary 3rd short and narrow; sclerotized ring moderately short; functional spermathecae 0.055–0.066 by 0.037–0.040 mm ( $n = 3$ ) and 0.051–0.058 by 0.035–0.037 mm ( $n = 2$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, slender apicolateral processes; caudal margin with a short mesal emargination. Ninth sternum with a broad, moderately deep caudomedian emargination; the ventral membrane not spiculate. Basistyle elongate, tapering distally; dorsal root moderately long and stout, ventral root with prominent anteriorly and posteriorly directed processes, anterior process very large; dististyle nearly straight, tapering, distally curved to a pointed apex. Aedeagus with a broad, deep basal arch, lateral arms moderately slender, expanded distally; shoulders of aedeagus with a pair of stout, posteriorly directed, pointed processes; distal median process long and stout with truncate apex. Paramere with large, anterolaterally directed basal knob; main stem stout, with a prominent, subapical ventral lobe; distal portion of stem recurved to a slender, pointed apex, and with 4–5 lateral fringing spines.

**Discussion.** *Culicoides pretoriensis* is somewhat similar to *kobae* Cornet & Chateau. See the discussion of *kobae* for characters separating the two species.

**Bionomics.** The immature stages and larval habit of *pretoriensis* are undescribed. The adult feeding habits are unknown; however, it may have a preference for smaller mammals based on its high number of antennal sensilla.

**Distribution.** Kenya, Senegal, South Africa, Zimbabwe.

**Material Examined.** SENEGAL: 6 km N of Kedougou, Galerie Forest, light trap, 28-VI-73, 1 ♀, 1 ♂. ZIMBABWE: Kariba, 1,675 ft elev., D. R. Birkenmeyer, blacklight trap, 15-X-67, 1 ♂; same data, XI-69, 2 ♀♀, 1 ♂.

*Culicoides radiomaculatus* Khamala & Kettle  
(Fig. 41)

*Culicoides radiomaculatus* Khamala & Kettle 1971: 85 (male, female). Holotype: ♀, Kaimosi, Kenya, C. Khamala, light trap, 10-X-66 (BMNH). Paratypes: 2 ♀♀, 3 ♂♂, same data as holotype (1 ♂, BMNH; 1 ♀, 1 ♂, USNM; 1 ♀, 1 ♂, MRAC).

**Diagnosis.** A medium-sized, dark brown species. Female eyes narrowly separated; sensilla coeloconica on antennal segments 3, 5, 7, 9, 11–14; proboscis long. Wing with a pale spot present in basal cell just anterior to the r-m crossvein; pale spot entirely distad of r-m crossvein at base of cell R5; pale spots present over middle of veins M1 and M2. Female abdomen with spermathecae unequal; sclerotized ring with a wide anterior collar. **Male Genitalia.** Ninth tergum with short, slender apicolateral processes; shoulders of aedeagus with a pair of posteriorly directed, pointed processes; distal median process of aedeagus long and stout with truncate apex; stem of paramere without subapical ventral lobe.

**Female** (from paratype). Wing length 1.12 mm. **Head.** Dark brown. Eyes narrowly separated by a distance slightly less than the diameter of 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 20–14–15–15–16–14–15–16–30–28–29–30–39; A.R. 1.25; sensilla coeloconica (with number per segment) on segments 3(6), 5(1), 7(1), 9(1), 11(1), 12(1), 13(1), 14(4). Third segment of maxillary palpus moderately expanded, with a large, rounded, moderately shallow sensory pit; P.R. 2.25. Proboscis long, P/H 0.96; mandible with 13 teeth.

**Thorax.** Dark brown. Legs dark brown, knees blackish; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a subbasal pale band, hindtibia broadly paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia moderately abundant over most of wing, especially in distal ½. Wing pattern distinctive; pale spot present in basal cell just anterior to the r-m crossvein; a rounded pale spot just distad of r-m crossvein at base of cell R5; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell, and a pale spot in distal portion well before apex; cell M1 with a subapical pale spot; cell M2 pale at base, and with pale spots just below median fork, above cubital fork, and at apex; pale spots over middle of veins M1 and M2; cell M4 with a large pale spot extending from middle of vein M3+4 to posterior wing margin; anal cell pale basally, and with a pale spot in distal portion just below apex of anal vein. Costal ratio 0.59.

**Abdomen.** Brown. Spermathecae unequal, ovoid, with short sclerotized necks widening from bases; rudimentary 3rd narrow; sclerotized ring short, with a wide anterior collar; functional spermathecae 0.055 by 0.036 and 0.046 by 0.031 mm.

**Male Genitalia.** Ninth tergum with tapering sides and short, slender apicolateral processes; caudal margin with a small, shallow median emargination. Ninth sternum with a broad, moderately shallow caudomedian emargination; the ventral membrane not spiculate. Dorsal root long and moderately slender, ventral root with prominent anteriorly and posteriorly directed processes, anterior process large; dististyle stout basally, nearly straight, distal por-

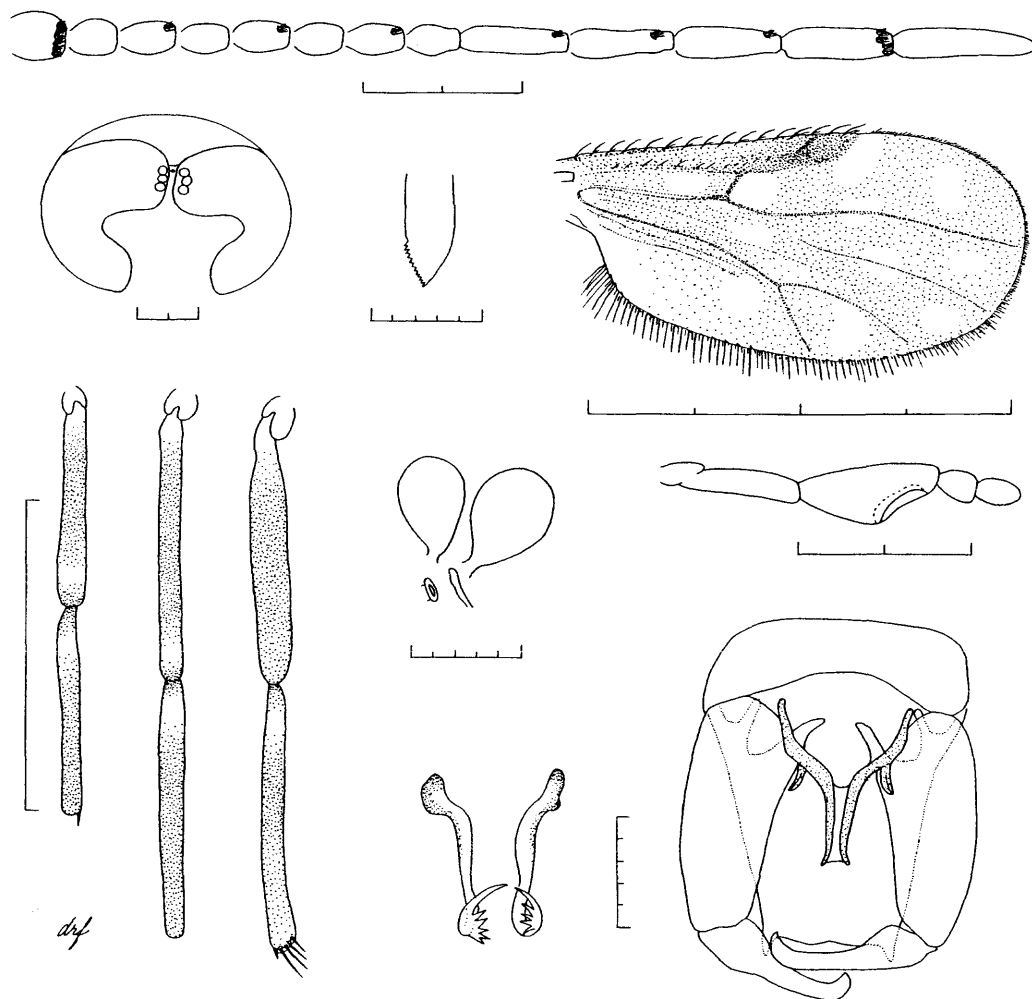


Fig. 41. *Culicoides radiomaculatus* (*similis* group). Adult female, male genitalia. (See key for scale.)

tion more slender, with curved, pointed apex. Aedeagus with a broad, deep basal arch, lateral arms moderately slender; shoulders of aedeagus with a pair of stout, posteriorly directed, pointed processes; distal median process of aedeagus long and stout, with a truncate apex. Paramere with a large, anterolaterally directed basal knob; main stem moderately straight and slender, without a subapical ventral lobe; distal portion recurved to a slender, pointed apex, and with a row of 4–5 lateral fringing spines.

**Discussion.** *Culicoides radiomaculatus* is easily distinguished from other members of the *similis* group in Kenya by the pale spot in the middle of the basal cell, the pale spots over veins M1 and M2, and by the antennal sensory pattern of 3, 5, 7, 9, 11–14. The male genitalia are somewhat similar to those of *accraensis*; however, the paramere does not have a subapical ventral lobe.

**Bionomics.** The immature stages and larval habitat of *Culicoides radiomaculatus* are undescribed. Khamala (1971) collected adults in East Africa from

a forest at Kaimosi, Kenya. Nothing is known about the adult feeding habits of *radiomaculatus*. The large number of antennal sensilla indicates it may feed primarily on birds and smaller mammals.

**Distribution.** Kenya.

**Material Examined.** KENYA: Kaimosi, C. Khamala, light trap, 10-X-66, 1 ♀ paratype, 1 ♂ paratype.

#### *Culicoides rarus* De Meillon (Fig. 42)

*Culicoides rarus* De Meillon 1936: 151 (female). Holotype: ♀, Transvaal, South Africa, Ofcolaco, 1933 (IMRJ).

*Culicoides tokwensis* De Meillon 1942b: 97 (male). Type: Tokwe River, Southern Rhodesia, C. V. Meeser, 21-I-42 (IMRJ).

*Culicoides fuscicaudae* Macfie 1947: 75 (female). Holotype: ♀, Wad Medani, Anglo-Egyptian Sudan, H. W. B. Barlow, at light, 28-I-46. Syntypes: 5 ♀♀, same data as holotype (BMNH).

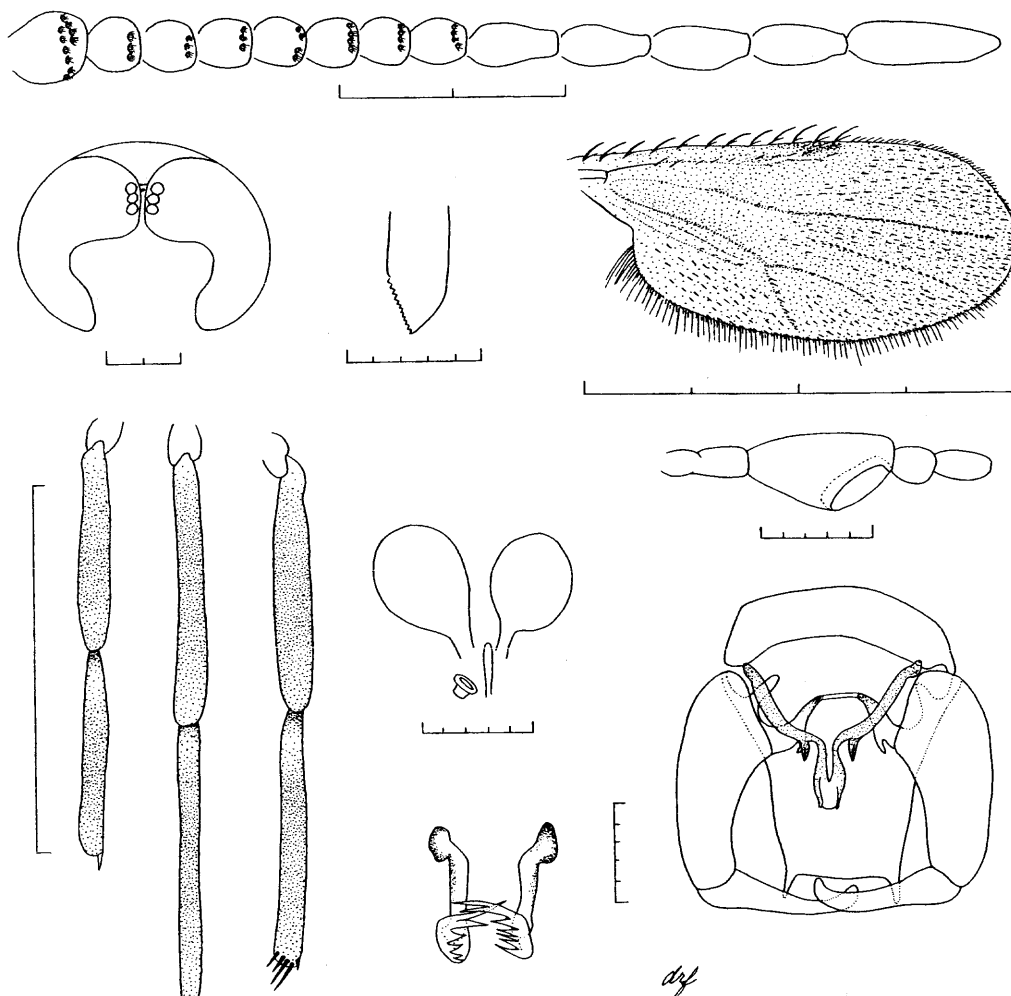


Fig. 42. *Culicoides ravus* (*similis* group). Adult female, male genitalia. (See key for scale.)

*Culicoides subravus* Cornet & Chateau 1970: 167 (male, female). Holotype: ♂ no. 1136, Niokolo-Koba National Park, Senegal, M. Cornet and R. Chateau, light trap, 22-V-69. Allotype: ♀ no. 1137, same data as holotype. Paratypes: ♀♀ no. 880 and 1138, ♂♂ no. 879 and 1135 (slides), 10 ♀♀, 10 ♂♂ (in alcohol), same data as holotype (ORSB).

**Diagnosis.** A medium-sized, brownish species. Female eyes very narrowly separated; sensilla coeloconica on antennal segments 3–10; 3rd segment of maxillary palpus greatly expanded, with a large, shallow sensory pit. Wing pale grayish, without a pattern, except paler proximal to radial cells. Female abdomen with spermathecae unequal; sclerotized ring with a wide anterior collar. **Male Genitalia.** Ventral roots of basistyle with anterior processes connected by a very narrow hyaline membrane; shoulders of aedeagus with a pair of posteriorly directed, pointed processes; distal median process long and stout with truncate apex; stem of paramere with a subapical ventral lobe.

**Female.** Wing length 0.92 mm (0.80–1.06 mm,

$n = 10$ ). **Head.** Dark brown; antenna and palpus paler. Eyes very narrowly separated by a distance less than the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 19–11–12–12–12–12–13–19–20–20–20–33; A.R. 1.12 (1.08–1.19,  $n = 10$ ); sensilla coeloconica (with number per segment) on segments 3(4–10), 4(1–3), 5(2–3), 6(1–3), 7(1–4), 8(1–4), 9(1–4), 10(1–4). Third segment of maxillary palpus moderately to greatly expanded, with a large, rounded, shallow sensory pit; P.R. 2.19 (1.70–2.32,  $n = 10$ ). Proboscis moderately short, P/H 0.65 (0.56–0.73,  $n = 10$ ); mandible with 12 teeth (10–14,  $n = 10$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, fore- and midfemora slightly paler apically; tibiae each with a subbasal pale band, and paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia abundant over most of wing except near base. Wing pale grayish, without pattern, except paler proximal to radial cells. Costal ratio 0.57 (0.53–0.59,  $n = 10$ ).

**Abdomen.** Brown. Spermathecae dark brown, unequal, ovoid, with long, parallel-sided necks; rudimentary 3rd narrow; sclerotized ring short, with wide anterior collar; functional spermathecae 0.064 by 0.041 mm (0.057–0.074 by 0.035–0.044 mm,  $n = 9$ ) and 0.061 by 0.036 mm (0.057–0.071 by 0.033–0.039 mm,  $n = 9$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, slender apicolateral processes. Ninth sternum with a broad, moderately shallow caudomedian emargination; the ventral membrane not spiculate. Basistyle elongate, tapering distally; dorsal root long and stout, ventral root very broad at base, with prominent anteriorly and posteriorly directed processes, anterior processes connected by a very narrow hyaline membrane; dististyle nearly straight, tapering, distal portion curving to a bluntly pointed apex. Aedeagus with a broad, deep basal arch, lateral arms slender, bases curving laterally; shoulders of aedeagus with a pair of posteriorly directed, pointed processes; distal median process long and stout, slightly expanded at midlength, with truncate apex. Paramere with a large, anterolaterally directed basal knob; main stem straight, stout, with a large subapical ventral lobe; distal portion recurved to a slender, pointed apex, and with 5–6 lateral fringing spines.

**Discussion.** Cornet & Nevill (1980) established the synonymy of *tokwensis* De Meillon, *fuscicaudae* Macfie, and *subravus* Cornet & Chateau with *ravus*. *C. ravus* is distinguished from other species with unmarked wings by the antennal sensory pattern of 3–10, the spermathecal ring with a wide anterior collar, and the male genitalia.

Khamala & Kettle (1971) incorrectly placed *ravus* (as *fuscicaudae*) in the *inornatipennis* group on the basis of female characters only because the male was then unknown.

Boorman (1979) reported a series of *Culicoides azerbaijhanicus* Dzhabarov collected in Kenya by Walker (a species with unmarked wings, somewhat similar in appearance to *ravus*); however, two of the females from Ikutha and one male from Kiboko were compared with specimens of *azerbaidzhanicus* from Afghanistan, West Pakistan, and the USSR and are apparently not the same species.

**Bionomics.** The immature stages of *Culicoides ravus* are undescribed.

Callot et al. (1967a) reared two males from a substrate sample of mud taken from a stream-fed pond serving as an animal watering hole at Ethiolo in eastern Senegal.

In East Africa, Khamala (1971) collected one adult (as *fuscicaudae*) from a high-altitude *Acacia* savanna and grassland at Nairobi, Kenya. Walker (1976) also collected adults (as *fuscicaudae*) in Kenya from *Acacia* woodland and grassland and from arid *Acacia-Commiphora* bushland.

The adult feeding habits of *ravus* are unknown; however, it may have a preference for smaller mammals based on its high number of antennal sensilla.

**Distribution.** Kenya, Mali, Morocco, Nigeria,

Senegal, South Africa, Sudan, Upper Volta, Zimbabwe.

**Material Examined.** NIGERIA: Kankiya, B. McMillan, II-57, light trap, 5 ♂♂; Vom, W. Taylor, at light, 12-III-75, 2 ♂♂; same data, 10-V-75, 1 ♀; same data, 12-XII-75, 1 ♀; same data, 19-III-76, 3 ♀♀. SUDAN: Khartoum, P. Mellor, at light, 10-11-X-79, 1 ♀; same data, 12-13-X-79, 1 ♀; Soba, P. Mellor, at light, 16-17-X-79, 1 ♂. ZIMBABWE: Burma Valley, P. Gaddie, 1971, 1 ♀; Inyanga North, C. Green, 13-II-70, 1 ♂; Lupane, R. J. Phelps, truck trap, X-80, 1 ♀; Magondi Reserve, C. Green, 3-II-70, 2 ♀♀; same data, 14-II-70, 1 ♀; Nkai Region, Gwampa River, R. J. Phelps, 30-III-81, 2 ♀♀, 1 ♂; Rokoneshe, R. J. Phelps, XI-73, 1 ♀.

#### *Culicoides similis* Carter, Ingram & Macfie (Fig. 43)

*Culicoides similis* Carter, Ingram & Macfie 1920: 255 (male, female). Types: Accra, Gold Coast (Ghana), A. Ingram and J. W. S. Macfie, on lab windows; and Oblogo, A. Ingram and J. W. S. Macfie, reared from material taken from a canoe in the Densu River, I-IV-20 (BMNH). Paratype: ♀ no. 59 MK, Accra, Gold Coast, A. Ingram (MRAC, ex BMNH).

**Diagnosis.** A medium-sized, dark brown species. Female eyes very narrowly separated; sensilla coeloconica on antennal segments 3, 5, 7–10; 3rd segment of maxillary palpus greatly expanded; proboscis very short. Wing pattern similar to that of *expectator*; pale spot just distad of r-m crossvein at base of cell R5; small pale spot on anterior margin just distad of 2nd radial cell, and a smaller pale spot just below and distal to the former. **Male Genitalia.** Ventral membrane of 9th sternum spiculate; ventral roots of basistyle with anterior processes connected by a narrow hyaline membrane; distal median process of aedeagus broad basally, tapering to a long, slender, pointed apex; stem of paramere with a subapical ventral lobe.

**Female.** Wing length 0.91 mm (0.76–1.01 mm,  $n = 12$ ). **Head.** Dark brown. Eyes very narrowly separated by a distance less than the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 16–10–10–11–11–11–13–20–21–22–24–33; A.R. 1.30 (1.20–1.47,  $n = 11$ ); sensilla coeloconica (with number per segment) on segments 3(2), 5(1), 7(1), 8(1), 9(1), 10(2). Third segment of maxillary palpus greatly expanded, with a small, rounded, moderately deep sensory pit; P.R. 1.93 (1.81–2.05,  $n = 12$ ). Proboscis very short, P/H 0.50 (0.46–0.52,  $n = 12$ ); mandible with 10 minute teeth (9–10,  $n = 12$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with a subapical pale band; tibiae each with a sub-basal pale band and pale apically; hindtibial comb

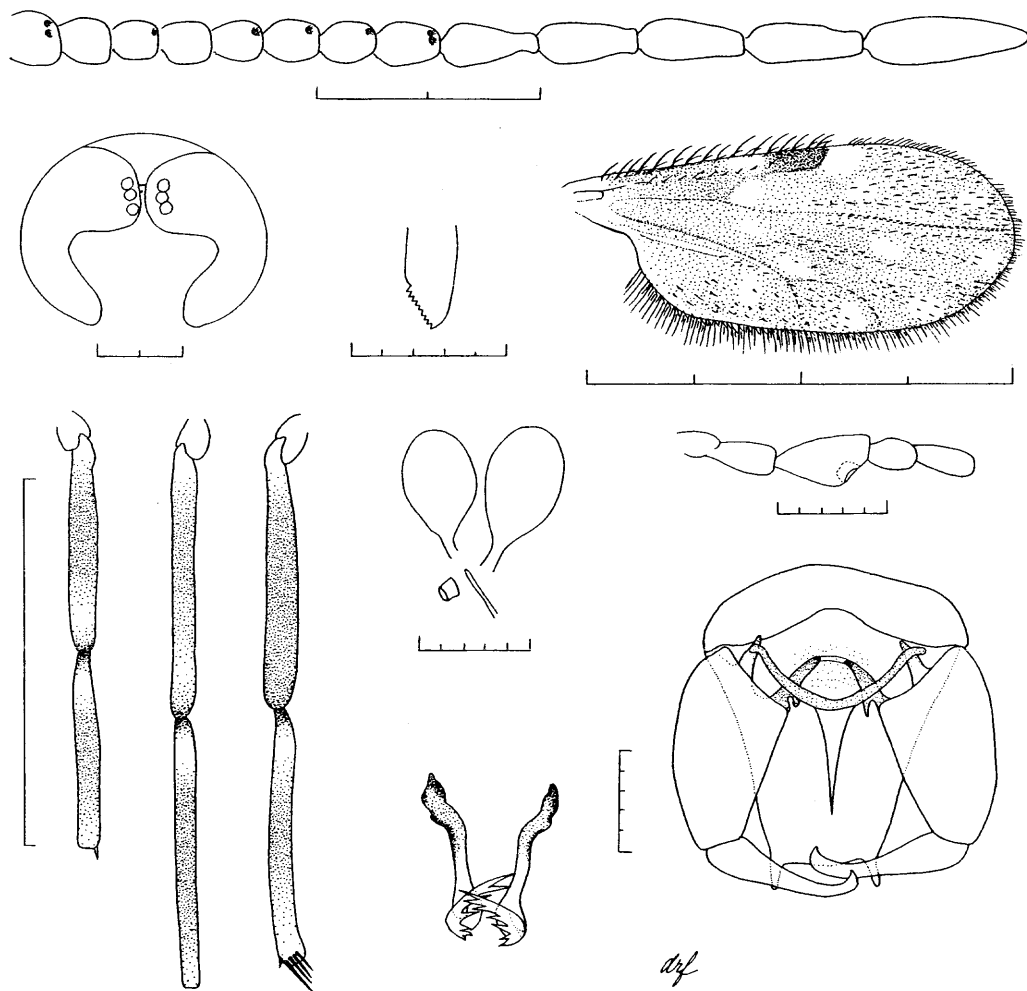


Fig. 43. *Culicoides similis* (*similis* group). Adult female, male genitalia. (See key for scale.)

with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia moderately abundant over most of wing, except at base. Wing with a pale spot just distad of r-m crossvein at base of cell R5, extending anteriorly to costal margin; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell, a smaller spot just below and distal to the former, and a spot at apex; cell M1 with a narrow pale streak in basal portion, expanding at middle to a large, broad, squarish pale area proximal to vein M2, and with a pale spot at apex; cell M2 pale basally, and with pale spots just below median fork, just above cubital fork, and at apex; cell M4 with a large pale spot extending from vein M3+4 to posterior wing margin; anal cell pale basally and along wing margin, coalescing with a pale spot in distal portion of cell. Costal ratio 0.54 (0.51–0.58,  $n = 12$ ).

**Abdomen.** Brown. Spermathecae unequal, ovoid, with long sclerotized necks; rudimentary 3rd nar-

row; sclerotized ring short to moderately long; functional spermathecae 0.064 by 0.039 mm (0.058–0.072 by 0.035–0.044 mm,  $n = 12$ ) and 0.060 by 0.035 mm (0.053–0.064 by 0.031–0.038 mm,  $n = 11$ ).

**Male Genitalia.** Ninth tergum with tapering sides and moderately long, slender apicolateral processes; caudal margin straight. Ninth sternum with a broad, moderately shallow caudomedian emargination; the ventral membrane spiculate. Dorsal root of basistyle long and stout, tapering to a pointed apex, ventral root with prominent anteriorly and posteriorly directed processes, anterior processes connected by a narrow hyaline membrane; dististyle nearly straight, tapering distally to a moderately curved, pointed apex. Aedeagus with a broad, moderately deep basal arch; lateral arms slender, bases curving laterally; distal median process broad basally, tapering to a long, slender, pointed apex. Paramere with a large, anterolaterally directed basal knob; main stem moderately

stout, slightly sinuate, with a large subapical ventral lobe; distal portion of stem recurved to a slender, pointed apex, and with about 6 lateral fringing spines.

**Discussion.** *Culicoides similis* is most similar to *exspectator* and *tropicalis* but can be distinguished by wing pattern, antennal sensory pattern, and the male genitalia. The male aedeagus of *similis* is distinctive in having a long, pointed, distal median process.

**Bionomics.** Ingram & Macfie (1921) described the larva and pupa of *similis*. They did not recover larval exuviae from any isolated rearings but described the larva from three specimens almost ready to pupate; the pupal structures were clearly visible through the cuticle and appeared to be identical to those of *similis*.

In Ghana, Ingram & Macfie (1921) reared numerous adults from larvae and pupae taken in soft mud at the edges of pools and puddles at Accra and from sandy mud taken from a washing place in the Densu River at Oblogo. Adults also were reared from rotting wood taken from canoes on the bank of the Densu River (Carter et al. 1920, Macfie & Ingram 1923).

Callot et al. (1967a) reared one female in eastern Senegal from a substrate sample of mud taken from a stream-fed pond serving as an animal watering site. Cornet & Chateau (1970) found *similis* adults abundant in Senegal, particularly in the dry season, where its habitat was mud bordering residual ponds.

In Kenya, Lubega & Khamala (1976) reared *similis* from mud at the edges of ponds and puddles exposed or covered by growing vegetation and usually frequented by livestock for drinking water; and from decaying banana stems. At Eruwa, Nigeria, Dipeolu & Ogunrinade (1976) collected adults emerging from boggy ground of a rocky hill site and at the Opeki River from underneath partially waterlogged canoes and from rotting vegetation along the river bank. At the University of Ibadan research farm, they (Dipeolu & Ogunrinade 1977) collected small numbers of adults from emergence traps placed at the margins of a dairy cattle drinking trough and from the margins of an open drain leading from a slaughterhouse. Emergence continued throughout the year, with peaks in June and August.

Clastrier & Wirth (1961) reported adults from rice swamps in Nigeria. In Kenya, Khamala (1971) collected numerous adults from various savanna zone types. Walker (1976) collected *similis* from all ecological zones, including high-altitude forest and grassland, moist *Combretum* woodland and grassland, semiarid *Acacia* woodland and grassland, arid *Acacia-Commiphora* bushland, and very arid scrubland and semidesert.

Braverman & Hulley (1979) predicted the host preference of *similis* to be larger mammals based on the low number of antennal sensilla. In Nigeria, Dipeolu (1976b) collected *similis* by light trap in moderate numbers from around livestock pens from

all areas except mangrove swamp; adults were most numerous in the forest zone, with a period of peak numbers of engorged females from 0500 to 0700 hours. At the University of Ibadan research farm (Dipeolu 1976a), *similis* was collected from sites near wild animals, being most abundant around the duiker and kob enclosures (33% bloodfed).

**Distribution.** Egypt, Ethiopia, Gambia, Ghana, India, Kenya, Mali, Morocco, Nigeria, Senegal, South Africa, Sudan, Tanzania, Thailand, Upper Volta, Zimbabwe.

**Material Examined.** ETHIOPIA: Wallo Province, Asaita, near Awash River, 500 ft elev., V. H. Lee, light trap, 26-27-IX-74, 1 ♀, 1 ♂. GAMBIA: West Kiang District, Keneba, D. H. Murphy, light trap, 17-VI-56, 1 ♂; same data except rice swamp, sticky trap among leaf bases of *Elaeis guineensis*, 26-III-59, 1 ♀; same locality, light trap, 20-XI-59, 2 ♀♀, 1 ♂; North Kombo District, Mandinari, swamp, D. H. Murphy, light trap, 15-II-60, 7 ♀♀, 1 ♂. NIGERIA: Kankiya, B. McMillan, light trap, 1956, 1 ♀; same data, II-57, 3 ♀♀, 2 ♂♂. ZIMBABWE: Burma Valley, P. Gaddie, 1971, 1 ♂; Inyanga North, C. Green, 13-II-70, 1 ♀; Kariba, 1,675 ft elev., D. R. Birkenmeyer, blacklight trap, 20-X-67, 1 ♀; same data, 25-XI-67, 1 ♀; Magondi Reserve, R. J. Phelps, II-70, 1 ♀; same data except C. Green, 3-II-70, 1 ♀.

#### *Culicoides tropicalis* Kieffer

(Fig. 44)

*Culicoides tropicalis* Kieffer 1913: 10 (female).

Syntypes: 4 ♀♀ no. 65 K, Taveta, British East Africa, station no. 65, 20-III-12 (MHNP).

*Culicoides babrius* De Meillon 1943: 112 (male).

Holotype: ♂, Norton, Southern Rhodesia, Hunyani River, C. V. Meeser, no date. Paratypes: 2 ♂♂, same data as holotype (IMRJ).

*Culicoides exspectator* of Callot, Kremer & Molet; not Clastrier.

**Diagnosis.** A medium-sized, dark brown species. Female eyes very narrowly separated; sensilla coeloconica on antennal segments 3-10; 3rd segment of maxillary palpus greatly expanded, with a large, moderately shallow sensory pit; proboscis very short. Wing pattern similar to *exspectator*; wing with a pale spot just distad of r-m crossvein at base of cell R5; pale spot over vein M1, just below the pale spot on anterior margin in cell R5. **Male Genitalia.** Ventral root of basistyle very stout, truncate, with only a faint indication of anterior and posterior processes; lateral arms of aedeagus each composed of 2 sclerites, basal sclerite with a large, triangular knob and more slender, curved, posteriorly directed process, distal sclerite angel wing-shaped; distal median process of aedeagus long and stout with truncate apex, sides with a pair of long, slender processes; stem of paramere with subapical ventral lobe.

**Female.** Wing length 0.98 mm (0.92-1.06 mm,  $n = 10$ ). **Head.** Dark brown. Eyes very narrowly

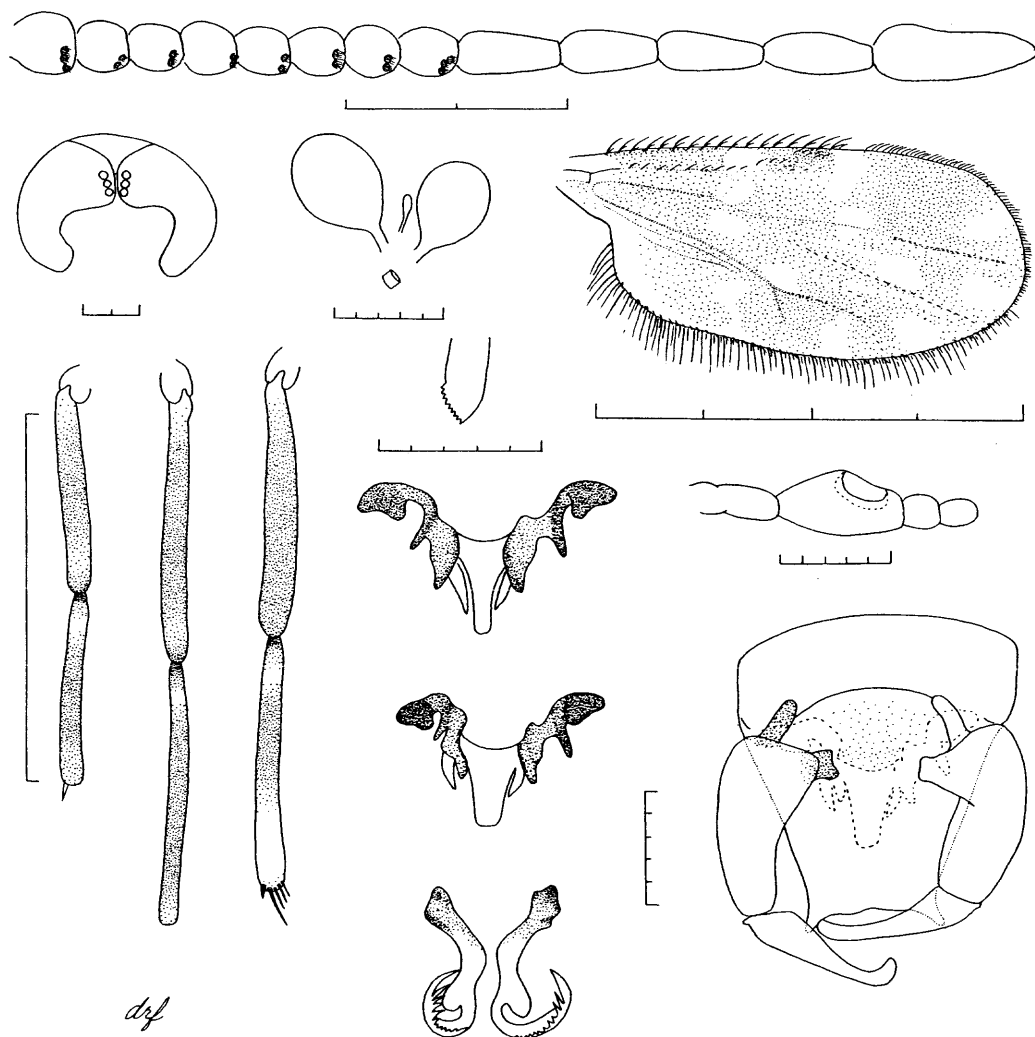


Fig. 44. *Culicoides tropicalis* (similis group). Adult female, male genitalia. (See key for scale.)

separated by a distance less than the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 17-11-10-10-11-11-11-13-18-21-21-23-31; A.R. 1.21 (1.13-1.33,  $n = 10$ ); sensilla coeloconica (with number per segment) on segments 3(2-3), 4(1-2), 5(1-2), 6(1-2), 7(1-2), 8(2-3), 9(2-3), 10(2-3). Third segment of maxillary palpus greatly expanded, with a large, moderately shallow sensory pit; P.R. 1.93 (1.76-2.17,  $n = 10$ ). Proboscis very short, P/H 0.53 (0.51-0.56,  $n = 10$ ); mandible with 9 minute teeth (8-9,  $n = 10$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, fore- and midfemora each with an indistinct subapical pale band; tibiae each with a subbasal pale band, fore- and midtibiae slightly paler apically, hindtibia broadly pale apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia moderately abundant over

most of wing except basal portion. Wing pattern similar to those of *expectator* and *similis*; wing with a pale spot mostly distad of r-m crossvein at base of cell R5 and extending anteriorly to costal margin; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell, and a pale spot at apex; pale spot over middle of vein M1, below pale spot on anterior margin of cell R5; cell M1 with a narrow streak in basal portion, expanding at middle to a broad, squarish pale area proximal to vein M2, and with a pale spot at apex; cell M2 pale basally, and with a narrow pale streak through proximal  $\frac{2}{3}$  of cell, coalescing with pale spots just below median fork and just above cubital fork; a short pale streak in distal portion of cell M2, beginning just above apex of proximal streak, and directed proximal to vein M1, and with a pale spot at apex of cell; cell M4 with a pale spot extending from vein M3+4 to posterior wing margin; anal cell pale basally and along posterior margin, coalescing with a trans-



verse pale spot in distal portion. Costal ratio 0.55 (0.53–0.56,  $n = 10$ ).

**Abdomen.** Brown. Spermathecae unequal, ovoid, with long, parallel-sided necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.055 by 0.035 mm (0.048–0.064 by 0.033–0.037 mm,  $n = 7$ ) and 0.045 by 0.032 mm (0.040–0.048 by 0.030–0.035 mm,  $n = 7$ ).

**Male Genitalia.** Ninth tergum with tapering sides, flaring distally, apicolateral processes moderately stout with rounded apices; caudal margin nearly straight. Ninth sternum with a very shallow caudomedian emargination; the ventral membrane spiculate. Dorsal root of basistyle long and stout with rounded apex, ventral root short and very stout, truncate, with only a faint indication of anterior and posterior processes; dististyle nearly straight, distally tapering to a curved, bluntly pointed apex. Aedeagus with a broad, moderately deep basal arch; lateral arms each composed of 2 sclerites: proximal sclerite very heavily sclerotized, basal portion triangular, extending into a long, slender, posteriorly curving, pointed process; distal sclerite angel wing-shaped, posteriorly directed, less heavily sclerotized; distal median process of aedeagus long and stout with truncate apex, sides with a pair of long, moderately slender, apically pointed, posteriorly directed processes, narrowly separated from median process. Paramere with a large basal knob, basal portion of stem directed anterolaterally; main stem stout and slightly sinuate, with a large, subapical ventral lobe; distal portion recurved, tapering to a slender, pointed apex, and with 8–10 lateral fringing spines, the spines increasing in length toward apex.

**Discussion.** Kremer (1972a) redescribed *tropicalis* from four female syntypes and discussed its synonymy with *babrius* De Meillon and *expectator* sensu Callot et al. (1967b, male). The female that Khamala & Kettle (1971) described is not *tropicalis* (which has an antennal sensory pattern of 3–10 rather than 3, 7–10) but is a closely related, undescribed species (Cornet, personal communication).

The male of *tropicalis* is easily distinguished from other members of the *similis* group in Kenya by its distinctive genitalia, including the nearly truncate ventral root of the basistyle and the lateral arms of the aedeagus, each comprising two sclerites.

**Bionomics.** The immature stages of *Culicoides tropicalis* are undescribed.

In Kenya, Lubega & Khamala (1976) reared adults (as *babrius*) at Lake Nakuru National Park from water-logged mud from freshwater marshes overgrown with *Cyperus* and *Typha*, and from mud from the edges of other bodies of water exposed or covered by growing vegetation and usually frequented by livestock. Braverman (1978) found *tropicalis* to be a dominant species in the Salisbury area of Zimbabwe along drainage canals with mud low in organic matter; adults also were

reared from mud around puddles rich in organic matter and along streams and drainage canals with mud intermediate to poor in organic matter. Breeding occurred throughout the year except during March, September, and December.

Khamala (1971) collected adults (as *babrius*) by light trap in East Africa from a forest in Tanzania and from a savanna in Kenya. Walker (1976) collected adults (also as *babrius*) in Kenya from high-altitude forest and grassland, moist *Combretum* woodland and grassland, and arid *Acacia-Commiphora* bushland.

In South Africa, Nevill & Anderson (1972) found adults (as *babrius*) most abundant in a control (garden) trap and in a sheep trap. Dipeolu (1976b) collected adults (as *babrius*) in low numbers from near cattle and small ruminant pens in the forest, northern Guinea, and Sudan zones of Nigeria.

**Distribution.** Angola, Kenya, Nigeria, South Africa, Tanzania, Uganda, Zimbabwe.

**Material Examined.** ZIMBABWE: Salisbury, E. T. Reid, light trap, III-56, 1 ♀; same data, 30-V-56, 5 ♀♀, 1 ♂; same data, IX-56, 1 ♀, 1 ♂; same data, II-57, 1 ♀; same data, IV-57, 2 ♀♀; same data, VI-57, 1 ♀, 1 ♂; same data, VIII-57, 2 ♂♂.

### Unplaced Kenya Species

**Kenya Species.** *C. adersi* Ingram & Macfie, *C. bedfordi* Ingram & Macfie, *C. coarctatus* Clastrier & Wirth, *C. eriodendroni* Carter, Ingram & Macfie, *C. gambiae* Clastrier & Wirth, *C. kaimosiensis* Khamala & Kettle, *C. shimoniensis* Khamala & Kettle, *C. stercorarius* Khamala & Kettle, *C. walkeri* Boorman.

### *Culicoides adersi* Ingram & Macfie (Fig. 45)

*Culicoides adersi* Ingram & Macfie 1923: 56 (female). Holotype: ♀, Lamu, Kenya, S. A. Neave, 18-II-12. Cotypes: 4 ♀♀, same data as holotype; 4 ♀♀, Pigaduri, Zanzibar, biting natives, W. M. Aders, 18-IX-17 (BMNH).

**Diagnosis.** A medium-sized, brownish species. Female eyes moderately separated; distal antennal segments not greatly elongated; sensilla coeloconica on segments 3, 11–14; 3rd segment of maxillary palpus stout, with numerous sensilla scattered on distal ½. Hindtibial comb with 6 spines. Wing with pale spots distinct, greatly enlarged and confluent; 2nd radial cell dark to apex; macrotrichia sparse at apex. Female abdomen with 2 ovoid, functional spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with short, stout apicolateral processes; dorsal root of basistyle long and simple, ventral root with anteriorly and posteriorly directed processes; aedeagus with a deep basal arch, distal median process with rounded apex; parameres sep-

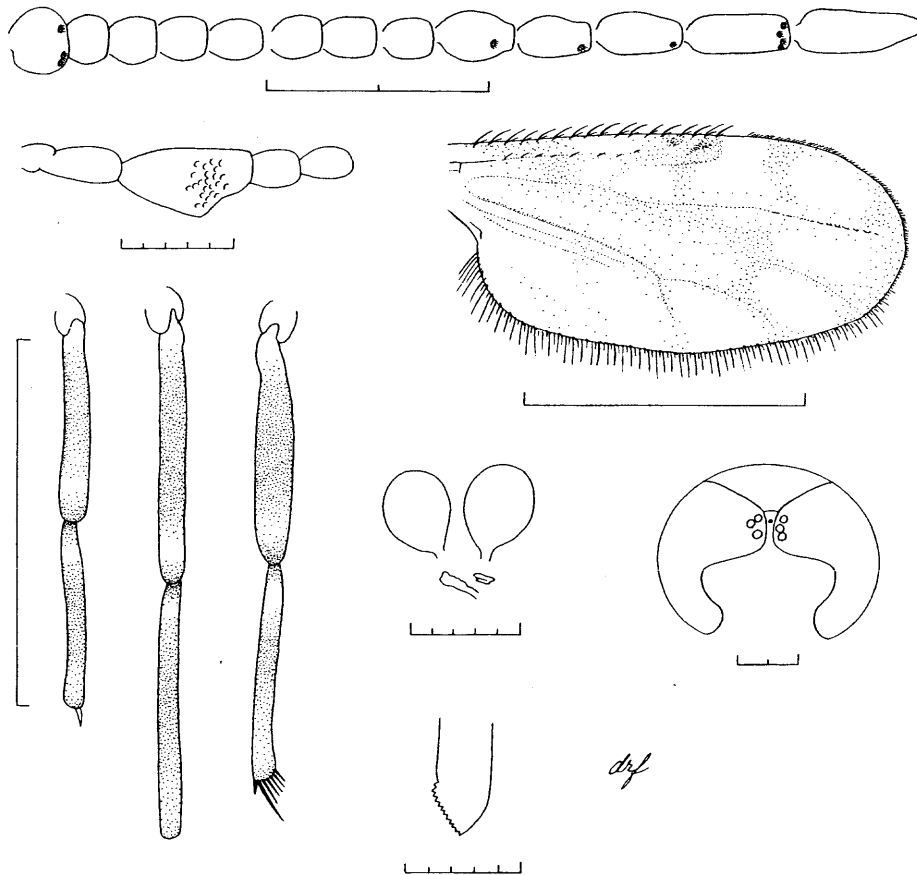


Fig. 45. *Culicoides adersi* (unplaced). Adult female. (See key for scale.)

arate, stem tapering, recurved distally to a pointed apex with distal fringing hairs.

**Female.** Wing length 0.84 mm (0.75–0.91 mm,  $n = 8$ ). **Head.** Dark brown; proximal flagellar segments, and palpus except for 3rd segment paler. Eyes moderately separated by a distance slightly less than the diameter of 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 15–9–10–10–11–11–11–12–17–16–18–21–27; A.R. 1.13 (1.03–1.18,  $n = 5$ ); sensilla coeloconica (with number per segment) on segments 3(2–4), 11(1), 12(1), 13(1–2), 14(3–5). Third segment of maxillary palpus stout, with sensilla scattered over distal  $\frac{1}{2}$  in numerous, shallow pits; P.R. 1.88 (1.65–2.00,  $n = 7$ ). Proboscis moderately short, P/H 0.67 (0.64–0.70,  $n = 4$ ); mandible with 11–13 teeth ( $n = 4$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, each with a subapical pale band; tibiae each with a subbasal pale band, and pale apically; hindtibial comb with 6 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia sparse, confined to apex, and around wing near margin, especially in cell R5. Wing with distinct pattern of large, mostly confluent pale spots; 2nd radial cell dark to apex; wing

base broadly pale; pale spot over r-m crossvein extending broadly to costal margin; cell R5 with pale spots at middle and at apex, broadly filling most of cell; cell M1 with a pale spot filling distal  $\frac{1}{2}$ ; basal  $\frac{3}{4}$  of cell M2 broadly pale, distal portion with a pale spot filling most of remainder of cell; cell M4 with a pale spot filling almost entire cell; anal cell broadly pale over basal  $\frac{1}{2}$ , and with a pale spot filling most of distal  $\frac{1}{2}$ ; vein M1 with a broad pale streak over distal  $\frac{3}{4}$  of vein; stigmal area darkened. Costal ratio 0.59 (0.57–0.61,  $n = 8$ ).

**Abdomen.** Brown. Spermathecae dark brown, slightly unequal, ovoid, with short sclerotized necks; rudimentary 3rd narrow; sclerotized ring very short, with a wide anterior collar; functional spermathecae 0.048 by 0.032 mm (0.045–0.051 by 0.031–0.033 mm,  $n = 5$ ) and 0.042 by 0.031 mm (0.037–0.048 by 0.030–0.032 mm,  $n = 5$ ).

**Male Genitalia** (from description and illustration of Khamala & Kettle [1971]). Ninth tergum with tapering sides and short, stout apicolateral processes; caudal margin straight. Ninth sternum with a broad, moderately deep caudomedian emargination; ventral membrane not spiculate. Dorsal root of basistyle long, apically pointed, ventral root with prominent, pointed, anteriorly and posteriorly di-

rected processes; dististyle nearly straight, tapering to a curved, pointed apex. Aedeagus with a very deep basal arch, lateral arms slender; distal median process short and stout with rounded apex. Paramere with stout basal knob, basal portion of stem bent anterolaterally; distally tapering; distal portion of stem recurved to a slender, pointed apex with distal fringing hairs.

**Discussion.** The combination of very large, confluent pale spots on the wing, the antennal sensory pattern of 3, 11–14, the scattered sensilla on the distal surface of the third palpal segment, the hindtibial comb with six spines, the abdomen with two functional spermathecae, and the spermathecal ring with an apparently enlarged anterior collar separates *adersi* from all other Afrotropical *Culicoides*. The male of *adersi* had been unknown until Khamala & Kettle's (1971) description. The males collected by Khamala were not available for study, and his illustration of the genitalia is not suitable for reproduction; however, the genitalia are basically unremarkable except for the anterior and posterior processes of the ventral root and the setose apices of the parameres.

Khamala & Kettle (1971) placed *adersi* in its own group based on its distinctiveness from other *Culicoides* spp.; however, it should be left unplaced until its affinities to other *Culicoides* are better understood.

**Bionomics.** The immature stages of *adersi* are undescribed.

Lubega & Khamala (1976) reared adults from intertidal mud in mangrove swamps and other coastal marshes of Kenya, and Khamala (1971) reported 13 specimens collected from the savannas of Kenya.

Braverman & Hulley (1979) predicted the host preference of *adersi* to be larger mammals based on the low number of antennal sensilla. Part of the type series was described by Ingram & Macfie (1923) from four females collected while biting natives in September at Pigaduri, Zanzibar (Tanzania).

**Distribution.** Kenya, Tanzania.

**Material Examined.** KENYA: Mombasa, Port Reitz, biting man and monkey, VIII-59, 4 ♀♀; no locality, A. R. Walker, 1971–1974, 1 ♀. TANZANIA: Zanzibar Protectorate, Pemba Island, Wete, D. T. B. Welch, II-35, 4 ♀♀.

#### *Culicoides bedfordi* Ingram & Macfie (Fig. 46)

*Culicoides bedfordi* Ingram & Macfie 1923: 57 (male, female). Holotype: ♀, Transvaal, South Africa, Onderstepoort, G. Bedford, 22-IX-14. Paratypes: 2 ♂♂, same data as holotype (1 in bedroom at 0600 hours) (BMNH).

**Diagnosis.** A medium-sized, dark brown species. Female eyes narrowly separated; sensilla coeloconica on antennal segments 3–15; 3rd segment of maxillary palpus greatly expanded, with a large,

moderately shallow sensory pit. Wing with prominent pale spots over r-m crossvein and on anterior margin just distad of the 2nd radial cell; less distinct pale spots near base of cell M1, in cell M2 at midlength, and in distal portion of cell M4 and anal cell. Female abdomen with 2 functional spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with long, stout apicolateral processes; 9th sternum with a deep caudomedian emargination, ventral membrane not spiculate; dorsal and ventral roots of basistyle long; aedeagus with a deep basal arch, distal median process long and stout, tapering to a truncate apex; parameres separate, with stout basal knob bent laterally, stem tapering distally to a slender, laterally directed, pointed apex.

**Female.** Wing length 1.03 mm. **Head.** Dark brown; proximal antennal segments paler. Eyes narrowly separated by a distance equal to the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 17–11–12–13–13–13–13–21–23–25–27–39; A.R. 1.29; sensilla coeloconica (with number per segment) on segments 3(5), 4(1), 5(1), 6(1), 7(1), 8(1), 9(1), 10(1), 11(1), 12(1), 13(1), 14(3), 15(2). Third segment of maxillary palpus greatly expanded, with a large, moderately shallow sensory pit; P.R. 2.09. Proboscis moderately long, P/H 0.84; mandible with 12 teeth.

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, forefemur pale subapically and through middle to base, midfemur paler apically; tibiae each with a subbasal pale band and paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia abundant over most of wing except near base. Wing base broadly pale, extending caudally into basal portion of anal cell; a large, distinct pale spot over r-m crossvein extending to costal margin, and a moderately distinct pale spot in cell R5 on anterior margin just distad of 2nd radial cell; cell M1 with an indistinct pale spot near base; cell M2 with a broad, diffuse pale area at midlength; cell M4 with an indistinct pale spot extending from vein M3+4 to posterior wing margin; anal cell with an indistinct transverse pale spot in distal portion; membrane infuscated pale grayish brown, veins darker. Costal ratio 0.56.

**Abdomen.** Brown. Spermathecae dark brown, appearing approximately subequal, ovoid, with short sclerotized necks (both functional spermathecae collapsed); rudimentary 3rd narrow; sclerotized ring short.

**Male Genitalia.** Ninth tergum with tapering sides and long, stout apicolateral processes; caudal margin with a short mesal emargination. Ninth sternum with a broad, deep caudomedian emargination; the ventral membrane not spiculate. Dorsal root of basistyle long and moderately stout, ventral root long and slender, apex mesally directed; dististyle straight, stout, with a curving, pointed apex. Aedeagus with a deep, rounded basal arch; lateral

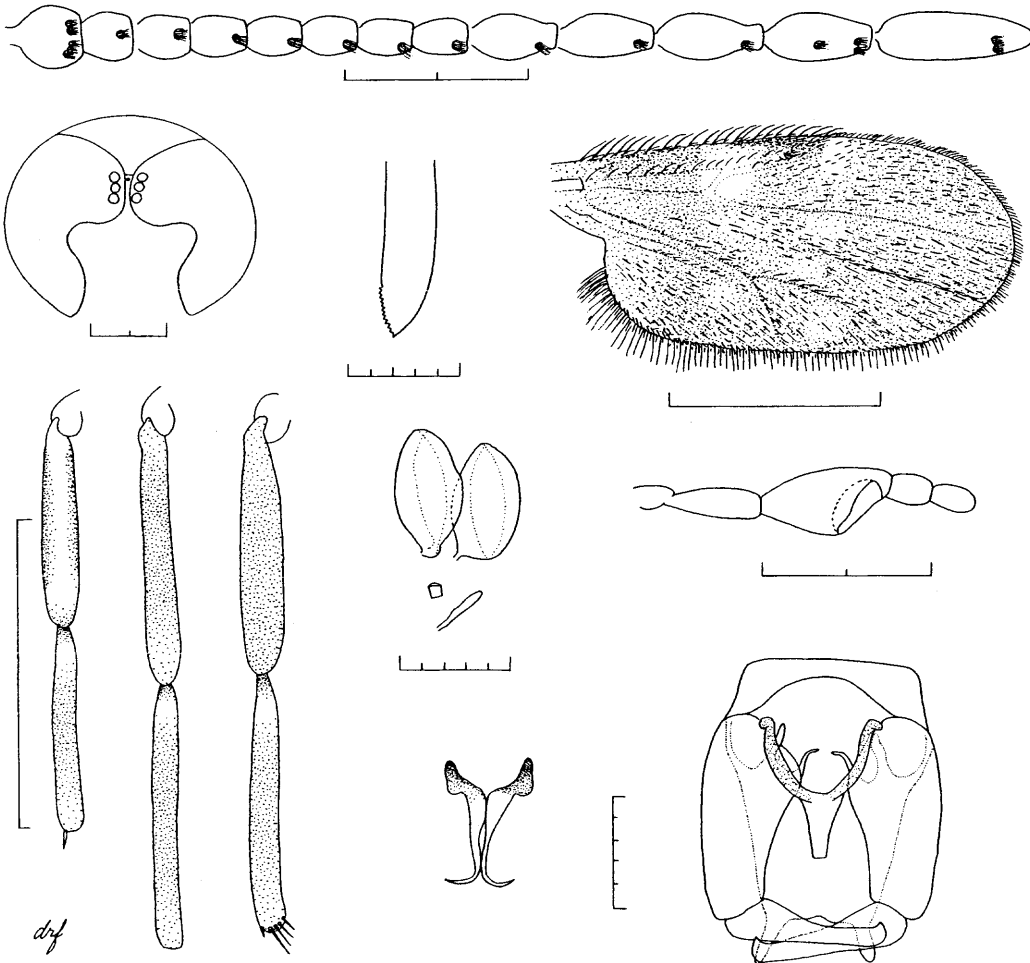


Fig. 46. *Culicoides bedfordi* (unplaced). Adult female, male genitalia. (See key for scale.)

arms moderately slender, bases laterally directed; distal median process long and stout, with truncate apex. Parameres separate; each with stout basal knob directed laterally; main stem tapering to a slender, laterally curved, pointed apex.

**Discussion.** Khamala & Kettle (1971) stated that the paratypes examined at the BMNH and other material from East Africa did not have the pale spot in the distal portion of cell R5 or the spot over the middle of vein M1 as illustrated by Ingram & Macfie (1923). As Fiedler (1951) pointed out, Ingram & Macfie probably examined females of *Culicoides dutoiti* De Meillon when they drew up the original description. Cornet (personal communication) noted that the identity of *bedfordi*, particularly of the female, is not well established. The description and illustration of the female presented herein are taken from specimens that Cornet feels are true *bedfordi*.

**Bionomics.** Nevill (1969) described and illustrated the fourth instar and pupa from South African material.

*Culicoides bedfordi* adults have been reared on

numerous occasions from a variety of habitats (some records may refer to closely related species). At Lake Nakuru National Park, Kenya (Khamala 1975), *bedfordi* was reared from immatures collected from mud and wet soil from river edges, from water-logged mud with decaying vegetation in a *Cyperus* marsh; from wet soil at the edges of rainwater pools in *Hyperrhenia-Chloris* grasslands, from water-logged mud of a *Typha* swamp, and from mud at the edge of artificial drainage trenches. Lubega & Khamala (1976) noted adults reared at Lake Nakuru from salty marshes overgrown with vegetation and contaminated with bird excreta. Braverman (1978) reared three females from mud samples taken at the edge of water bodies in the Salisbury area of Zimbabwe.

Hopkins (1952) reported adults of *bedfordi* reared from rotting banana and plantain stems in a banana plantation in Cameroon and also from rot hole material; however, these records need confirmation because it appears *bedfordi* does not typically breed in these situations.

*Culicoides bedfordi* adults have been taken at

various months of the year, but its annual seasonal distribution is unknown. Khamala (1971) collected *bedfordi* by light trap in East Africa from a forest zone (Kenya) and from a savannalike zone derived from forest (Tanzania). Walker (1976) collected adults from semiarid *Acacia* woodland and grassland and arid *Acacia-Commiphora* bushland in Kenya.

The host preference of *bedfordi* is unknown, although the high number of antennal sensilla indicate it may be primarily a bird feeder (as predicted by Braverman & Hulley 1979). Bedford (in Colaco 1946) reported females taken while they were biting horses in the daytime at Emseleni, Zululand.

**Distribution.** Cameroon, Kenya, South Africa, Sudan, Tanzania, Zimbabwe.

**Material Examined.** KENYA: No locality, A. R. Walker, 1971–1974, 1 ♀, 1 ♂. SOUTH AFRICA: Transvaal, Onderstepoort, R. Dutoit, 10-X-42, 1 ♀.

*Culicoides coarctatus* Clastrier & Wirth  
(Fig. 47)

*Culicoides coarctatus* Clastrier & Wirth 1961: 312 (male, female). Holotype: ♂, Kankiya, Nigeria, B. McMillan, at light, II-57 (MHNP). Paratypes: 2 ♂♂, 12 ♀♀, same data as holotype (3 ♀♀, 1 ♂, USNM).

**Diagnosis.** A medium-sized, dark brown species. Female eyes moderately separated; distal antennal segments not elongated; sensilla coeloconica usually on segments 3, 7, 9, 11, 13–14; 3rd segment of maxillary palpus moderately expanded, with a large, shallow sensory pit. Wing with a large pale spot over r-m crossvein extending anteriorly to costal margin and caudally into cell M2; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell; pale spots in distal portion of cells M1, M2, M4, and anal cell; cell M1 with a pale spot near base; cell M2 with a pale streak in basal ½ and a pale spot in distal portion below basal pale spot in cell M1. Female abdomen with 2 functional spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with long, basally stout apicolateral processes; 9th sternum with a deep caudomedian emargination, the ventral membrane spiculate; dorsal root of basistyle moderately short and stout, ventral root absent; aedeagus with a shallow basal arch, distal median process short and stout with truncate apex; parameres fused subbasally by a sclerotized bridge, forming a pair of long, slender, bladelike processes with pointed apices.

**Female.** Wing length 0.95 mm (0.85–1.08 mm,  $n = 19$ ). **Head.** Dark brown; proximal antennal segments paler. Eyes moderately separated by a distance equal to the diameter of 1 ocular facet; without interfacetal setae. Distal antennal segments not greatly elongated, antenna with flagellar lengths in mean proportion of 15–12–12–12–13–

12–13–13–17–17–18–20–28; A.R. 0.99 (0.92–1.05,  $n = 19$ ); sensilla coeloconica (with number per segment) on segments 3(2–3), 5(0–1), 7(1), 8(0–1), 9(0–1), 11(0–1), 12(0–1), 13(0–1), 14(2–3); sensory pattern usually 3, 7, 9, 11, 13–14, extra sensilla occasionally present on some or all of segments 5, 8, and 12, rarely sensilla absent from segments 9, 11, or 13. Third segment of maxillary palpus moderately expanded, with a large, shallow sensory pit; P.R. 2.34 (2.09–2.53,  $n = 18$ ). Proboscis moderately long, P/H 0.79 (0.75–0.83,  $n = 19$ ); mandible with 12 teeth (11–14,  $n = 18$ ).

**Thorax.** Scutum and postscutellum dark brown, scutellum yellowish brown, pleurae brown. Legs brown, knees darker; femora pale basally, fore- and midfemora paler apically; tibiae each with a subbasal pale band and paler apically, especially on hindtibia; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia moderately abundant over most of wing except basally. Wing with a moderately distinct pattern; wing base broadly pale, extending caudally into basal portion of anal cell; a large pale spot over r-m crossvein, narrowing somewhat to costal margin and extending caudally into cell M2; cell R5 with a large pale spot on anterior margin just distad of 2nd radial cell, and a smaller pale spot at apex; cell M1 with a broad pale spot near base, and a pale spot at apex; cell M2 with a narrow pale streak in basal ½, coalescing with a pale spot in distal portion below basal pale spot in cell M1, and with a pale spot at apex of cell; cell M4 with a pale spot in distal portion proximal to posterior wing margin; anal cell with a large pale spot in distal portion, extending to posterior wing margin. Costal ratio 0.55 (0.52–0.57,  $n = 19$ ).

**Abdomen.** Brown. Spermathecae dark brown, unequal, ovoid, with short sclerotized necks; rudimentary 3rd and sclerotized ring short; functional spermathecae 0.063 by 0.041 mm (0.058–0.068 by 0.037–0.046 mm,  $n = 10$ ) and 0.056 by 0.038 mm (0.046–0.064 by 0.032–0.043 mm,  $n = 11$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, basally stout apicolateral processes; caudal margin slightly concave. Ninth sternum with a broad, deep caudomedian emargination; the ventral membrane spiculate. Basistyle stout; dorsal root moderately short and stout, ventral root absent; dististyle stout, slightly curving, tapering distally to a more slender, pointed apex. Aedeagus with a shallow basal arch; bases of lateral arms directed anterolaterally; sides of aedeagus tapering to a short, stout distal median process with truncate apex. Parameres fused subbasally by a transverse sclerotized bridge, forming a pair of posteriorly directed, slender, bladelike processes with pointed apices.

**Discussion.** Related species include *Culicoides confusus* Carter, Ingram & Macfie, and *C. clarkei* Carter, Ingram & Macfie, neither yet found in Kenya. *C. confusus* has reduced wing macrotrichia in the posterior cells, and the eyes are more narrowly separated; the central and posterior wing spots of

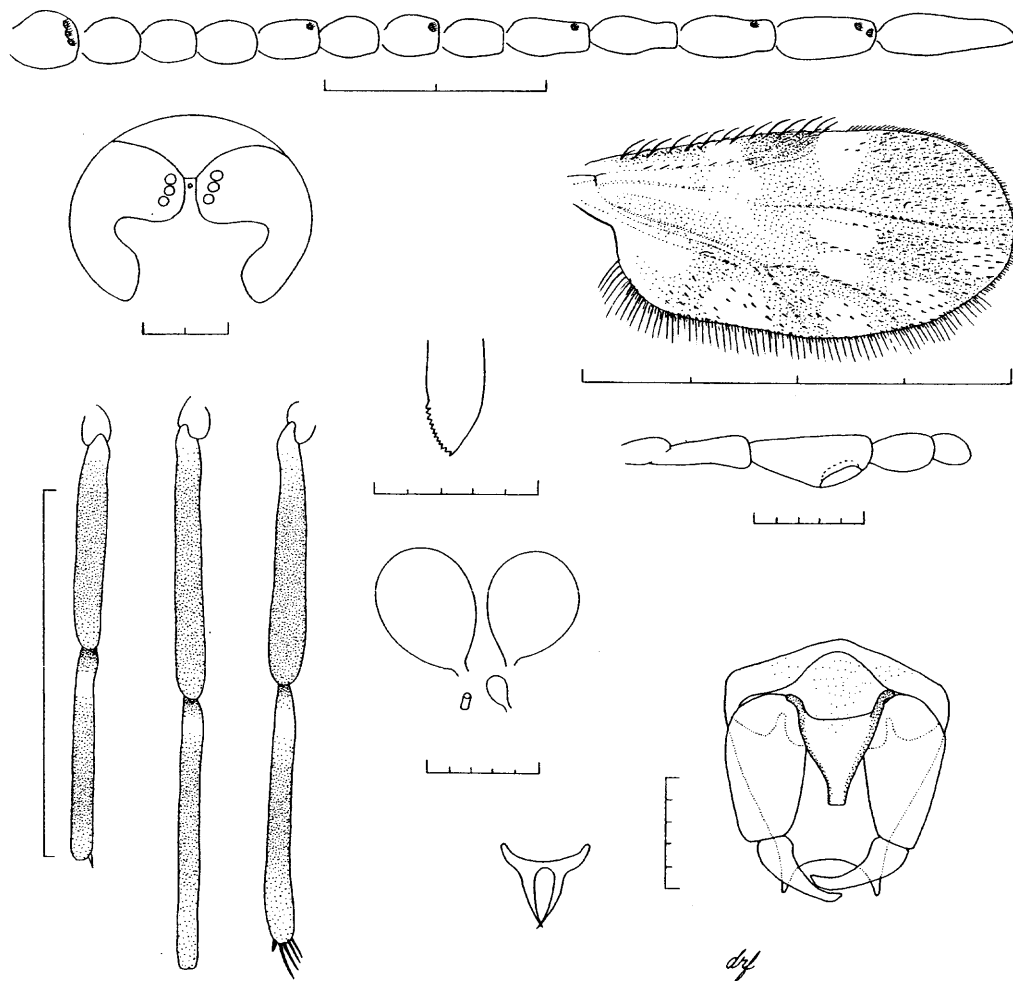


Fig. 47. *Culicoides coarctatus* (unplaced). Adult female, male genitalia. (See key for scale.)

*clarkei* are more apparent, and the macrotrichia extend to the base of the wing.

**Bionomics.** The immature stages and larval habitat of *Culicoides coarctatus* are undescribed.

The seasonal distribution of *coarctatus* is virtually unknown, except for a small number of records of adults taken from February to April and in August, September, and December.

Spielman collected females that were biting humans in a laboratory in Chad; otherwise, nothing is known about the feeding habits of *coarctatus*.

**Distribution.** Chad, Ethiopia, Kenya, Nigeria, Zimbabwe.

**Material Examined.** CHAD: Bol, females biting man in laboratory at night, A. Spielman, 11-XII-78, 10 ♀♀, 2 ♂♂. ETHIOPIA: Shoa Province, Sodere Resort, near Awash River and hot springs, 1,400 m elev., V. H. Lee, at light, 5-IV-75, 1 ♀. NIGERIA: Kankiya, B. McMillan, at light, II-57, 3 ♀ paratypes, 1 ♂ paratype. ZIMBABWE: Nkai Region, Nkapi Dam, R. J. Phelps, truck trap, 23-III-81, 2 ♂♂; Salisbury, E. T. Reid, light trap, IV-56, 1 ♀; same data,

IX-56, 1 ♀; same data, 13-XII-56, 1 ♀, 1 ♂; same data, IV-57, 1 ♀; same data, VIII-57, 1 ♀.

***Culicoides eriodendroni***  
Carter, Ingram & Macfie  
(Fig. 48)

*Culicoides eriodendroni* Carter, Ingram & Macfie 1920: 250 (female, pupa, larva). Holotype, ♀ and paratypes, ♀♀, Nsawam, Dodowah (about 25 mi NE Accra), and Oblogo, Gold Coast (Ghana), A. Ingram and J. W. S. Macfie, reared from rot holes in stump of a silk-cotton tree (*Eriodendron anfractuosum*), a mango tree (*Mangifera* sp.), and another tree, I-III-20 (BMNH).

**Diagnosis.** A large, dark brown species. Female eyes narrowly separated; proximal antennal segments elongate; sensilla coeloconica on segments 3, 11-15; 3rd segment of maxillary palpus greatly expanded distally, with a large, rounded, moderately deep sensory pit. Hindtibial comb with 4

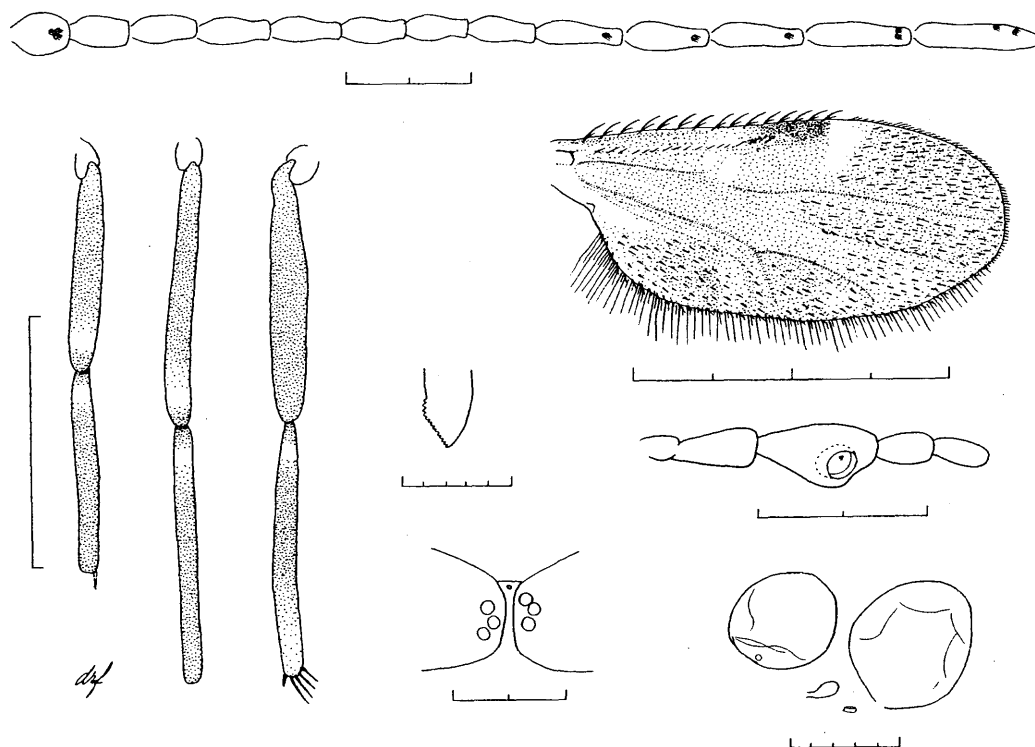


Fig. 48. *Culicoides eriodendroni* (unplaced). Adult female. (See key for scale.)

spines, the 2nd very slightly longer than the 1st. Wing with a large pale spot over r-m crossvein, not extending to costal margin; cell R5 with a pale spot on anterior margin just distad of 2nd radial cell; weak pale spots in distal portions of cell M4 and anal cell; other pale markings very weak, almost inapparent. Female abdomen with 2 functional spermathecae and rudimentary 3rd; sclerotized ring present at junction of ducts. Male unknown.

**Female.** Wing length 1.40 mm. **Head.** Dark brown; antenna paler. Eyes narrowly separated by a distance equal to the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 22-19-21-23-23-21-22-23-29-28-32-36-43; A.R. 0.97; sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(2), 15(2). Third segment of maxillary palpus greatly expanded distally, with a large, rounded, moderately deep sensory pit; P.R. 2.05. Proboscis moderately long, P/H 0.75; mandible with 14 teeth.

**Thorax.** Dark brown. Legs brown, knees darker; femora slightly paler basally, fore- and midfemora each with a subapical pale band, narrower on midfemur; tibiae each with a subbasal pale band, hindtibia paler apically; hindtibial comb with 4 spines, the 2nd very slightly longer than the 1st. Halter infuscated brownish.

**Wing.** Macrotrichia abundant over most of wing, except in costal and basal cells and at base of wing. Wing with a distinct pale spot over r-m crossvein,

not extending to costal margin, and a pale spot in cell R5 on anterior margin just distad of 2nd radial cell; weak pale spots in distal portion of cell M4 and anal cell; other distal pale spots very weak, almost inapparent; wing base pale just distad of basal arculus; wing membrane infuscated grayish brown, darker on anterior margin of cell R5; wing veins infuscated brownish, stigmal area darker. Costal ratio 0.59.

**Abdomen.** Dark brown. Spermathecae very dark brown, unequal, ovoid, without sclerotized necks; rudimentary 3rd short and slightly expanded; sclerotized ring very short; larger functional spermatheca 0.062 by 0.053 mm, smaller one partially collapsed, about 0.052 by 0.046 mm.

**Male.** Unknown.

**Discussion.** *Culicoides eriodendroni* is probably a complex of similar species, most of which are undescribed. The male, described as *eriodendroni* by Ingram & Macfie (1921), is actually the male of *nigripennis* (Cornet, personal communication). Khamala & Kettle (1971) incorrectly placed *eriodendroni* in the *neavei* group on the basis of wing macrotrichia distribution and structure of the third palpal segment; it should be left unplaced until the complex is better understood.

**Bionomics.** The larva and pupa of *eriodendroni* were described by Carter et al. (1920) from material collected in Ghana.

*Culicoides eriodendroni* is primarily a tree rot hole breeder. Adults were reared in Ghana from larvae obtained from rot holes in the stump of a

silk-cotton tree and a mango tree (Carter et al. 1920) and from decaying banana fiber from the base of a banana plant (Macfie & Ingram 1923). In the Salisbury area of Zimbabwe, Braverman (1978) reared adults (as the *eriodendroni* group) from rot holes and tree forks of the msasa (*Brachystegia speciformis* Benth.), the jacaranda (*Jacaranda mimosifolia* D. Don), the Cape fig (*Ficus capensis* Thunb.), and the mnondo (*Julbernardia globiflora* Benth. Troupin). Associated species in the rot holes belonged to the "*accraensis*" group (= *similis* group) and the *nigripennis* group.

Clastrier & Wirth (1961) reported *eriodendroni* taken at light in mid-June and mid-November in Gambia. In East Africa, Khamala (1971) collected a female from the forest zone of Kenya and another female from a savannalike zone in Uganda.

Braverman & Hulley (1979) predicted the host preference of *eriodendroni* to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Ghana, Kenya, South Africa, Uganda, Zimbabwe.

**Material Examined.** KENYA: Nairobi Province, Nairobi, Karen, 800 m W Karen Rd., 1,000 m S Bongani Rd., N fork Mbagathi River, Noad Farm, lower stream forest, 1,650 m elev., C. L. Bailey and K. J. Linthicum, light trap and CO<sub>2</sub>, 10-XII-81, 1 ♀.

***Culicoides gambiae* Clastrier & Wirth**  
(Fig. 49)

*Culicoides gambiae* Clastrier & Wirth 1961: 308 (male, female). Holotype: ♂, North Kombo, Lamin, Gambia, fringing forest near swamps, D. H. Murphy, light trap at top of 30-ft tower in forest canopy, 15-II-60 (IPA). Paratype: ♀, same data as holotype (USNM).

**Diagnosis.** A medium-sized, dark brown species. Female eyes narrowly separated; sensilla coeloconica on antennal segments 3-15; 3rd segment of maxillary palpus greatly expanded, with a large, moderately deep sensory pit. Hindtibial comb with 4 spines. Wing with a small, rounded pale spot over r-m crossvein, and a small pale spot on anterior margin just distad of 2nd radial cell. Female abdomen with 2 functional spermathecae and a rudimentary 3rd; sclerotized ring absent. **Male Genitalia.** Ninth tergum with long apicolateral processes; dorsal and ventral roots of basistyle long and simple; aedeagus with slender lateral arms and a deep basal arch; distal median process of aedeagus long and stout with truncate apex; parameres separate, stem tapering distally to a simple, pointed apex.

**Female.** Wing length 0.99-1.09 mm ( $n = 3$ ). **Head.** Dark brown; antenna and palpus lighter brown. Eyes narrowly separated by a distance equal to the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in mean proportion of 25-16-17-18-18-17-18-19-

31-32-35-36-45; A.R. 1.18-1.25 ( $n = 3$ ); sensilla coeloconica (with number per segment) on segments 3(5-6), 4(1), 5(1), 6(1), 7(1), 8(1), 9(1), 10(1), 11(1), 12(1), 13(1), 14(1-2), 15(1). Third segment of maxillary palpus greatly expanded at middle, with a large, rounded, moderately deep sensory pit; P.R. 2.05-2.28 ( $n = 3$ ). Proboscis moderately short, P/H 0.67-0.76 ( $n = 3$ ); mandible with 12-14 teeth ( $n = 3$ ).

**Thorax.** Dark brown. Legs brown, knees darker; femora pale basally, forefemur pale subapically; tibiae each with a subbasal pale band and paler apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter infuscated pale brown.

**Wing.** Macrotrichia abundant over most of wing except at base. Wing with only 2 distinct pale spots, including a small, rounded pale spot over the r-m crossvein, not extending anteriorly past the radial vein, and a small pale spot on anterior margin just distad of the 2nd radial cell; wing membrane infuscated pale grayish brown, veins slightly darker. Costal ratio 0.58 ( $n = 3$ ).

**Abdomen.** Brown. Spermathecae dark brown, subequal, ovoid, with short sclerotized necks; rudimentary 3rd narrow; sclerotized ring absent; functional spermathecae 0.050-0.055 by 0.037-0.042 mm and 0.046-0.055 by 0.037-0.042 mm ( $n = 3$ ).

**Male Genitalia.** Ninth tergum with tapering sides and long, moderately slender apicolateral processes with pointed apices; the caudal margin without emargination. Ninth sternum with a moderately deep caudomedian emargination; the ventral membrane not spiculate. Basistyle relatively short and stout; dorsal and ventral roots long and slender; dististyle straight, stout, slightly tapering, distally expanded to a rounded apex. Aedeagus with a deep basal arch; lateral arms slender, bases curved laterally; distal median process moderately long, stout, with truncate apex. Paramere with a large, laterally directed basal knob; stem stout, distally tapering to a curved, slender, pointed apex.

**Discussion.** The single female collected by Khamala (1971) from Kabete, Kenya, was described as having a sclerotized ring at the junction of the spermathecal ducts; however, the sclerotized ring was not observed in this female paratype or in other females examined from Gambia and Zimbabwe. *C. gambiae* was described and illustrated by Clastrier & Wirth (1961) as not having a sclerotized ring. It is probable that Khamala & Kettle's female is of another species.

*Culicoides gambiae* and members of the *nigripennis* group have similar wing patterns; however, the *nigripennis* group species are usually larger, the third palpal segment is broader, the pale spots on the wing are more apparent, and the spermathecae are spherical with long necks. *C. eriodendroni* also is similar; however, the wing has marginal pale spots, the eyes are more widely separated, and the proximal antennal segments are more elongate.



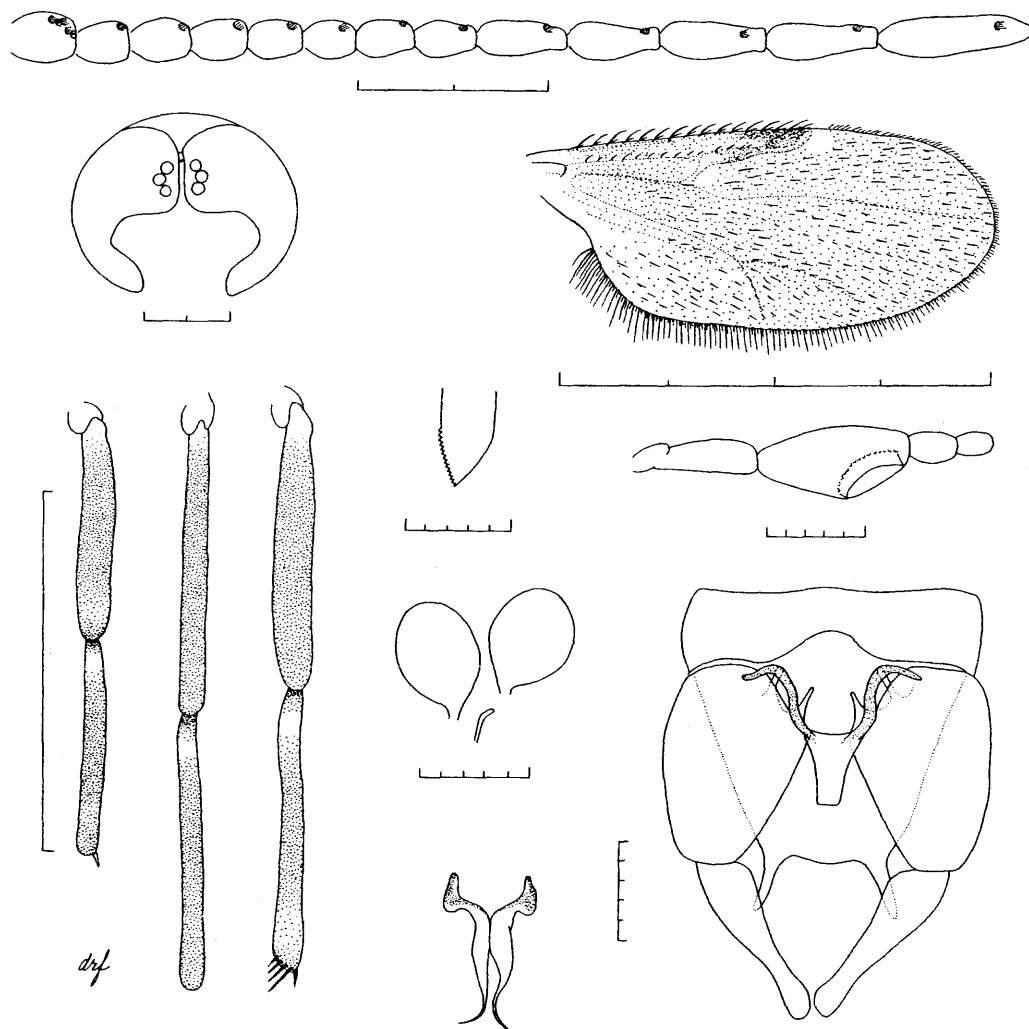


Fig. 49. *Culicoides gambiae* (unplaced). Adult female, male genitalia. (See key for scale.)

Khamala & Kettle (1971) placed *gambiae* along with other species in the *stercorarius* group based primarily on the similarity of the wings (poorly marked) and some basic similarities in the male genitalia; they noted that the group closely resembled the North American *biguttatus* group (Root & Hoffman 1937). However, most of the species in this artificial grouping should be left unplaced until their affinities are better known.

**Bionomics.** The immature stages of *Culicoides gambiae* are undescribed.

Callot et al. (1967a) reared several adults in eastern Senegal from mud taken from a pond serving as an animal watering site. In Nigeria, Dipeolu & Ogunrinade (1976) found *gambiae* breeding in boggy ground of a rocky hill site at Eruwa, and at the University of Ibadan research farm, they (1977) collected adults from emergence traps placed on the margins of a dairy cattle drinking trough.

Khamala (1971) collected a small number of adults from an *Acacia* savanna and grassland zone

at Kabete, Kenya. In Nigeria, Dipeolu (1976b) collected *gambiae* in low numbers from near cattle and small ruminant pens in the forest and derived savanna. Although the feeding preferences of *gambiae* are unknown, Braverman & Hulley (1979) predicted its host preference to be birds based on the high number of antennal sensilla.

**Distribution.** Gambia, Kenya, Mali, Nigeria, Senegal, Zimbabwe.

**Material Examined.** GAMBIA: North Kombo, Lamin, D. H. Murphy, light trap, 15-II-60, 1 ♀ paratype, 1 ♀, 1 ♂. KENYA: No locality, A. R. Walker, 1971-1974, 1 ♂. ZIMBABWE: Magondi Reserve, C. Green, 3-II-70, 1 ♀.

***Culicoides kaimosiensis* Khamala & Kettle**  
(Fig. 50)

*Culicoides kaimosiensis* Khamala & Kettle 1971: 58 (male, female). Holotype: ♀, Kaimosi, Kenya,

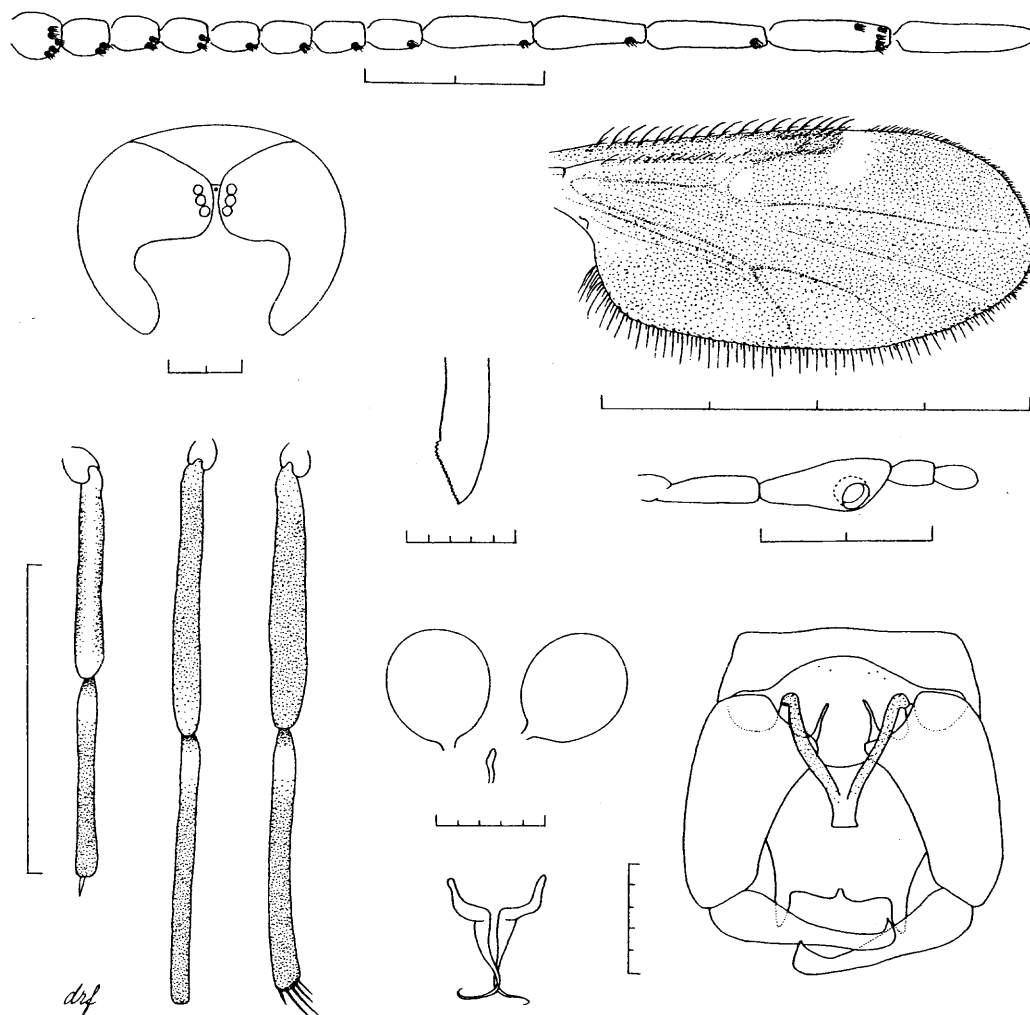


Fig. 50. *Culicoides kaimosiensis* (unplaced). Adult female, male genitalia. (See key for scale.)

C. Khamala, light trap, 10-X-66 (BMNH). Paratypes: 1 ♂, same data as holotype (?) (BMNH); 2 ♀♀, Amani, Tanzania, C. Khamala, light trap, 17-V-67 (1 ♀, USNM; 1 ♀, NMK).

**Diagnosis.** A large, dark brown species. Female eyes narrowly separated; distal antennal segments elongate; sensilla coeloconica on segments 3-14; 3rd segment of maxillary palpus with a single, rounded, deep sensory pit. Hindtibial comb with 4 spines. Wing with a distinct pale spot over r-m crossvein, extending anteriorly to costal margin, and a distinct spot on anterior margin just distad of 2nd radial cell; weak distal pale spots in cell M4 and anal cell; 2nd radial cell dark to apex; macrotrichia abundant over most of wing. Female abdomen with 2 functional spermathecae and a rudimentary 3rd; sclerotized ring absent. **Male Genitalia.** Ninth tergum with long, stout apicolateral processes; ventral membrane of 9th sternum very sparsely spiculate; dorsal and ventral roots of

basistyle long and simple; aedeagus with a deep basal arch, distal median process short and stout with truncate apex; parameres separate, basal knob with a long, slender, anteriorly directed process; stem of paramere distally tapering to a very slender, pointed apex.

**Female.** Wing length 1.26-1.49 mm ( $n = 2$ ). **Head.** Dark brown; proximal antennal segments pale. Eyes narrowly separated by a distance equal to the diameter of  $\frac{1}{2}$  an ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 26-18-19-19-20-20-20-20-40-39-45-42-48; A.R. 1.32-1.41 ( $n = 2$ ); sensilla coeloconica (with number per segment) on segments 3(4-5), 4(1-2), 5(1-2), 6(1-2), 7(1), 8(1), 9(1), 10(1), 11(1), 12(1), 13(1-2), 14(5-11). Third segment of maxillary palpus moderately expanded, with a moderately large, rounded, deep sensory pit; P.R. 2.09-2.50 ( $n = 2$ ). Proboscis very long, P/H 1.00-1.02 ( $n = 2$ ); mandible with 18-19 teeth ( $n = 2$ ).

**Thorax.** Dark brown. Legs brown, knees darker;

femora pale basally, forefemur pale apically and through middle to base, midfemur paler apically; tibiae each with a subbasal pale band; hindtibial comb with 4 spines, the 2nd from the spur very slightly longer than the 1st. Halter pale.

**Wing.** Macrotrichia abundant over most of wing. Wing with a distinct pale spot over the r-m crossvein, extending anteriorly to the costal margin, and a distinct spot on anterior margin just distad of the 2nd radial cell; wing base and base of anal cell pale; cell M2 with a narrow pale streak in basal  $\frac{1}{2}$ ; weak pale spots in distal portions of cell M4 and anal cell; wing membrane infuscated pale grayish brown, darker in basal cell and anterior portion of cell R5; wing veins infuscated brown, radial veins darker. Costal ratio 0.60–0.61 ( $n = 2$ ).

**Abdomen.** Brown. Spermathecae dark brown, subequal, ovoid, with short sclerotized necks; rudimentary 3rd narrow; sclerotized ring absent; functional spermathecae 0.060 by 0.048 and 0.058 by 0.048 mm.

**Male Genitalia.** Ninth tergum with tapering sides and long, stout, pointed, apicolateral processes; the caudal margin with a short mesal notch. Ninth sternum with a broad, moderately deep caudo-median emargination; the ventral membrane very sparsely spiculate. Dorsal root of basistyle long and stout, ventral root long and slender; dististyle nearly straight, tapering to a curved, pointed apex. Aedeagus with a deep, rounded basal arch, the arms laterally curved at bases; distal median process short and stout, with truncate apex. Paramere with a large, laterally directed basal knob with a long, slender, anteriorly directed process; stem tapering distally to a laterally curved, very slender, pointed apex.

**Discussion.** *Culicoides kaimosiensis* can be most easily distinguished by its wing pattern, the pale spot over the r-m crossvein extending to the wing margin; distal pale spots absent from cells R5, M1, and M2 and without a pale spot in cell M2 proximal to the median fork; and weak pale spots present in the distal portions of cell M4 and the anal cell. It can be distinguished from *stercorarius* Khamala & Kettle by its larger size, antennal sensory pattern of 3–14, longer distal antennal segments, and longer proboscis. The male can be separated from *stercorarius* by the fewer number of spicules on the ventral membrane of the ninth sternum, the shorter distal median process of the aedeagus, and the longer, more slender stem of the paramere.

Khamala & Kettle (1971) placed *kaimosiensis* in the *dekeyseri* group; however, it should be left unplaced until more is known about those species with poorly marked wings.

**Bionomics.** The immature stages and larval habitat of *Culicoides kaimosiensis* are undescribed. Khamala (1971) collected six adults from a forest zone at Kaimosi, Kenya. The feeding habits of *kaimosiensis* are unknown, although Braverman & Hulley (1979) predicted its host preference to be birds based on the high number of antennal sensilla.

**Distribution.** Kenya, Tanzania.

**Material Examined.** KENYA: Kaimosi, C. Khamala, light trap, 15-X-66, 1 ♂ paratype; Nairobi Province, Nairobi, Kabete, Dr. Davies' garden, C. L. Bailey and Kairo, light trap and CO<sub>2</sub>, 25-V-82, 1 ♀. TANZANIA: Amani, C. Khamala, light trap, 17-V-67, 1 ♀ paratype.

***Culicoides shimoniensis* Khamala & Kettle**  
(Fig. 53, center)

*Culicoides shimoniensis* Khamala & Kettle 1971: 54 (male). Holotype: ♂, Shimo-la-Tewa, Kenya, C. Khamala, light trap, 22-VII-66 (?). Paratype: 1 ♂, same data as holotype (BMNH).

**Diagnosis.** A medium-sized, brownish species; thorax yellowish. Third segment of maxillary palpus with a single, large sensory pit. Hindtibial comb with 4 spines. Wing with apex of 2nd radial cell pale. Wing extensively pale, with large pale spots over r-m crossvein; on anterior margin just distad of 2nd radial cell; at apices of cells R5, M1, and M2; at base of cell M1; in distal  $\frac{1}{2}$  of cell M2; filling most of cell M4; and in basal and distal portions of anal cell. **Male Genitalia.** Ninth tergum with long, stout, diverging apicolateral processes; dorsal and ventral roots of basistyle long and slender; aedeagus with a deep basal arch, distal median process long and stout, with a broadly rounded, nearly truncate apex; parameres separate, stem stout basally, tapering to a slender, pointed apex. Female unknown.

**Male** (described from paratype). Wing length 0.94 mm. **Head.** Brown; antenna and palpus paler. Third segment of maxillary palpus broad distally, with a large, shallow sensory pit.

**Thorax.** Yellowish; mesonotum with 3 longitudinal, pale brown bands, the median band longest; scutellum yellowish brown, darker at margins; postscutellum and lower pleuron brownish. Legs pale grayish brown, knees darker; femora and tibiae pale basally and apically; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia very sparse on distal  $\frac{1}{3}$  of wing in cells R5, M1, and M2. Wing extensively pale; a very large pale spot over the r-m crossvein extending anteriorly to the costal margin and caudally well into cell M2; a large pale spot on anterior margin just distad of 2nd radial cell, apex of 2nd radial cell pale; large, diffuse pale spots at apices of cells R5, M1, and M2; a large, elongate pale spot at base of cell M1; cell M2 with a large, elongate pale spot in distal  $\frac{1}{2}$ , just below pale area in base of cell M1; cell M4 with a large pale spot almost entirely filling cell; a very large pale area at wing base broadly extending into proximal  $\frac{1}{2}$  of anal cell; anal cell with a very large pale spot in distal portion; wing veins infuscated pale brown, radial veins darker. Costal ratio 0.55.

**Male Genitalia.** Abdomen brown. Ninth tergum with tapering sides and long, stout, diverging api-

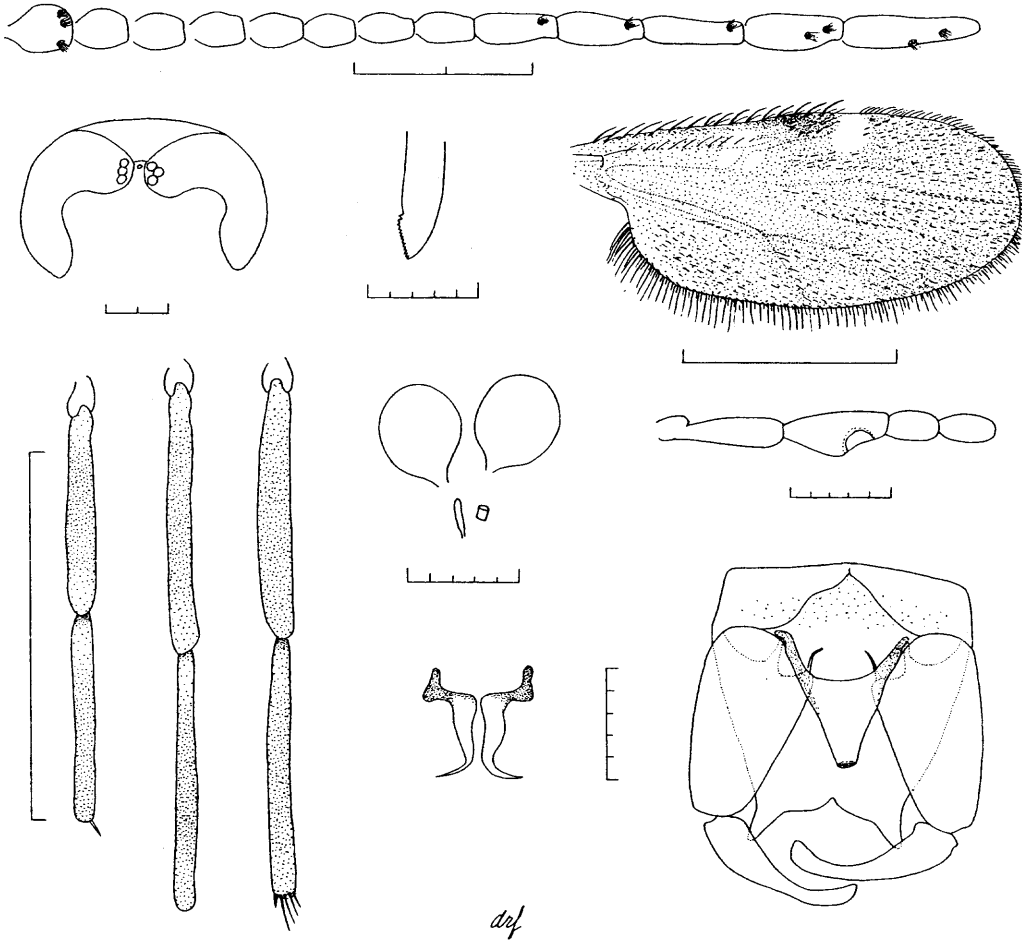


Fig. 51. *Culicoides stercorarius* (unplaced). Adult female, male genitalia. (See key for scale.)

collateral processes with pointed apices; the caudal margin with a short mesal emargination. Ninth sternum with a broad, shallow caudomedian emargination; the ventral membrane not spiculate. Basistyle broad over proximal  $\frac{1}{2}$ , tapering distally; dorsal and ventral roots long and slender; dististyle nearly straight, distally tapering to a curved, pointed apex. Aedeagus with a deep basal arch, lateral arms stout, curving laterally at bases; distal median process long and stout, with a broadly rounded, nearly truncate apex. Parameres separate; each with a large basal knob directed almost laterally; main stem stout basally, tapering distally to a slender, laterally curved, pointed apex.

**Female.** Unknown.

**Discussion.** *Culicoides shimoniensis* is known only from the male holotype and one male paratype. The published collection date of 1966 may be incorrect because the paratype male is dated 1967. Khamala & Kettle (1971) placed this species in its own group because its wing pattern is similar to that of *grahamii*, but its genitalia are entirely different. Examination of the paratype shows the

wing bears little resemblance to those of members of the *imicola* group; without the female, this species cannot be placed in its own group solely on the basis of the male genitalia.

**Bionomics.** The immatures and larval habitat of *shimoniensis* are unknown. The type specimens of *shimoniensis* were collected by light trap in Kenya during July.

**Distribution.** Kenya.

**Material Examined.** KENYA: Shimo-la-Tewa, C. Khamala, light trap, 22-VII-67, 1 ♂ paratype.

*Culicoides stercorarius* Khamala & Kettle  
(Fig. 51)

*Culicoides stercorarius* Khamala & Kettle 1971: 60 (male, female). Holotype: ♀, Tororo, Uganda, C. Khamala, light trap, 14-IV-66 (BMNH). Paratypes: 10 ♀♀, 1 ♂, same data as holotype (?) (1 ♀, 1 ♂, BMNH; 1 ♀, USNM; 1 ♀, MRAC; 7 ♀♀, NMK). Paratypes: 9 ♀♀, 5 ♂♂, Serere, Uganda, C. Khamala, light trap, 18-V-66 (1 ♂, BMNH; 1 ♂, USNM; 1 ♂, MRAC; 9 ♀♀, 2 ♂♂, NMK).

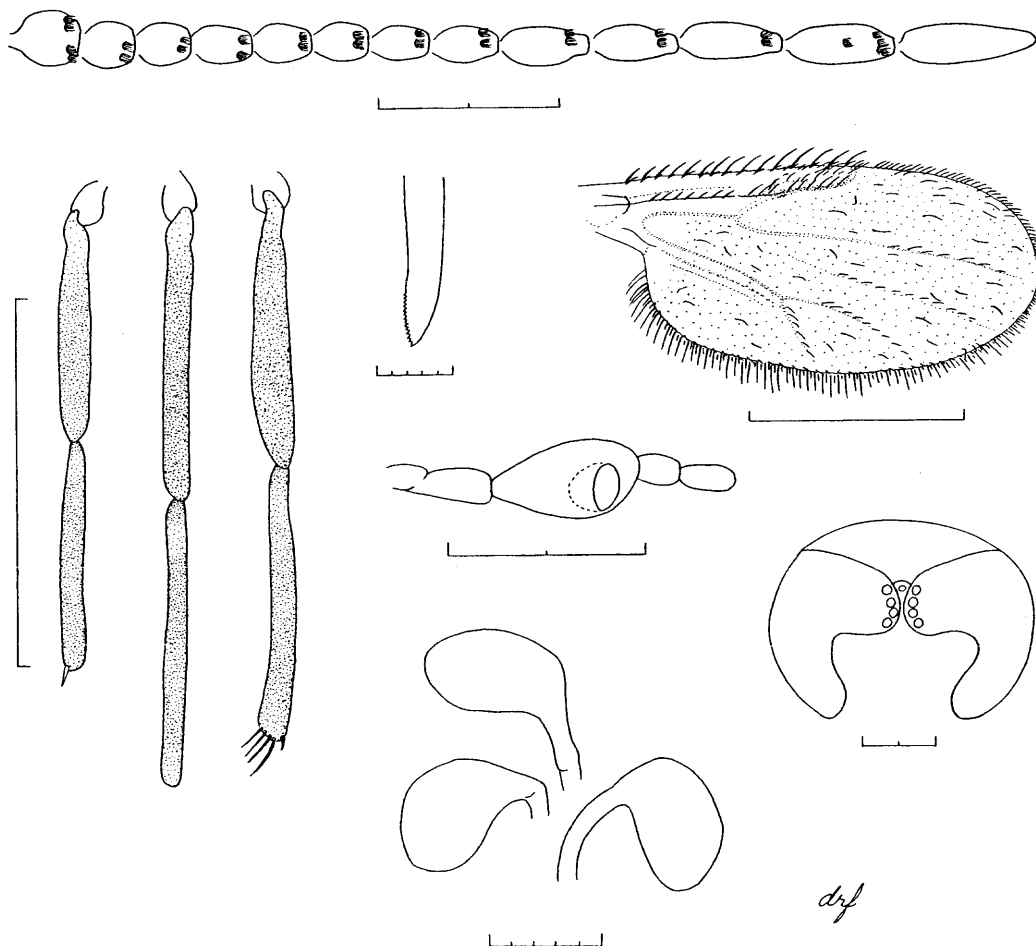


Fig. 52. *Culicoides walkeri* (unplaced). Adult female. (See key for scale.)

**Diagnosis.** A medium-sized, brownish species. Female eyes moderately separated; sensilla coeloconica on antennal segments 3, 11–15; 3rd segment of maxillary palpus moderately expanded, with a single, shallow sensory pit. Hindtibia with 4 spines. Wing with distinct pale spots over r-m crossvein and on anterior margin just distad of 2nd radial cell; basal  $\frac{1}{2}$  of cell M2 weakly pale; very weak pale spots in distal portions of cell M4 and anal cell; 2nd radial cell dark to apex; macrotrichia moderately abundant. Female abdomen with 2 functional spermathecae and a rudimentary 3rd; sclerotized ring present at junction of ducts. **Male Genitalia.** Ninth tergum with long, stout apicolateral processes; 9th sternum with the ventral membrane spiculate; dorsal and ventral roots of basistyle long and slender; aedeagus with a moderately deep basal arch, distal median process large and very broad, tapering to a truncate apex; parameres separate, stem short and stout, distally tapering to a pointed apex.

**Female** (described from 1 paratype). Wing length 0.99 mm. **Head.** Dark brown; antenna and palpus

slightly paler. Eyes moderately separated by a distance slightly greater than the diameter of 1 ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 16–13–13–13–13–13–14–15–19–21–25–24–34; A.R. 1.12; sensilla coeloconica (with number per segment) on segments 3(3), 11(1), 12(1), 13(1), 14(2), 15(2). Third segment of maxillary palpus moderately expanded, with a moderately large, rounded, shallow sensory pit; P.R. 2.50. Proboscis moderately long, P/H 0.75; mandible with 13 teeth.

**Thorax.** Dark brown; scutellum yellowish brown (dark brown according to Khamala & Kettle 1971). Legs brown; femora pale basally, weakly paler apically; tibiae each with a weak subbasal pale band, and weakly paler apically; hindtibia with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Macrotrichia moderately abundant over most of wing except basally. Second radial cell dark to apex. Wing with a distinct pale spot over r-m crossvein, extending anteriorly to the costal margin; cell R5 with a distinct pale spot on anterior margin just distad of the 2nd radial cell; wing base, basal

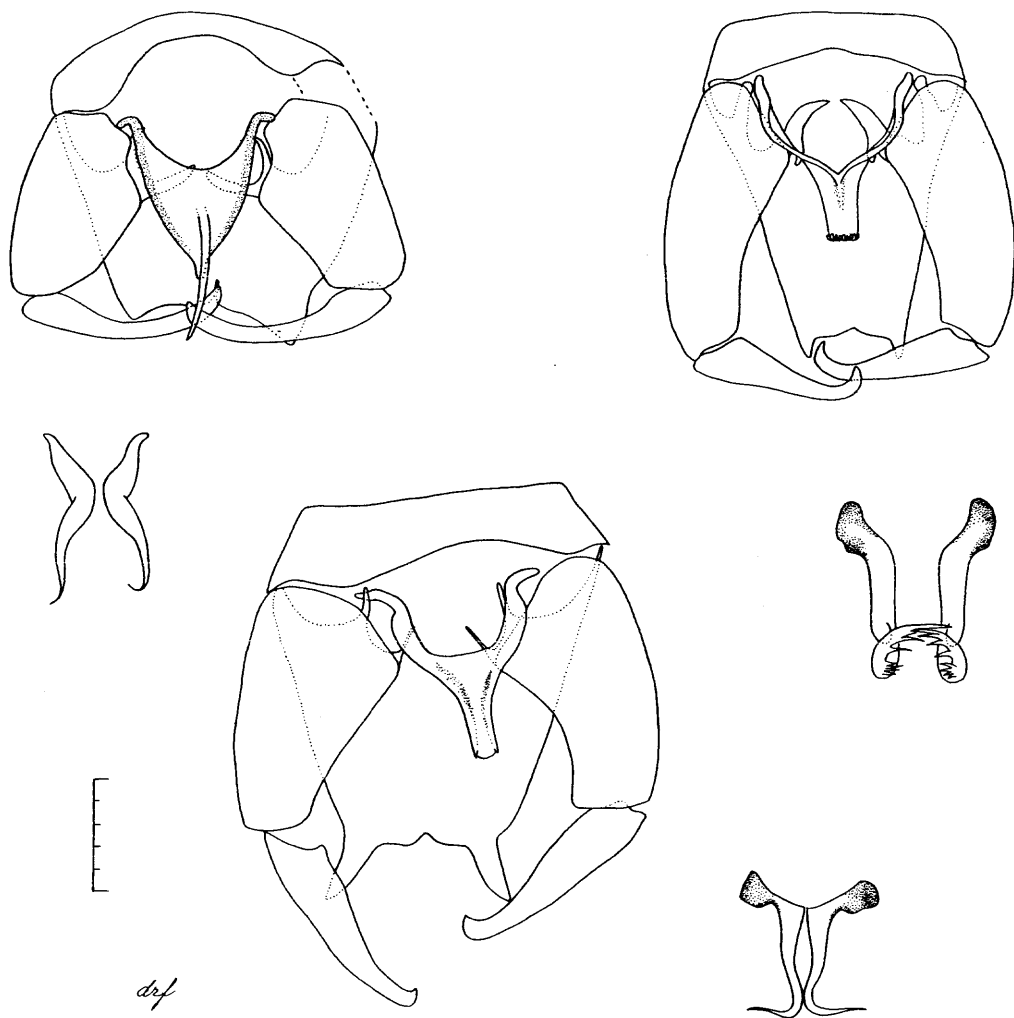


Fig. 53. Male genitalia, *Culicoides* spp. (left) *spinifer* (*imicola* group); (center) *shimoniensis* (unplaced); (right) *papillatus* (*similis* group).

$\frac{1}{2}$  of cell M2, and basal portion of anal cell weakly pale; very weak pale spots in distal portions of cell M4 and anal cell; wing membrane infuscated pale grayish brown, veins slightly darker. Costal ratio 0.57.

**Abdomen.** Brown. Spermathecae dark brown, subequal, ovoid, with very short sclerotized necks; rudimentary 3rd narrow; sclerotized ring short; functional spermathecae 0.053 by 0.039 and 0.048 by 0.039 mm.

**Male Genitalia** (described from 1 paratype). Ninth tergum with tapering sides and long, stout, somewhat triangulate apicolateral processes; the caudal margin with a short mesal emargination. Ninth sternum with a broad, deep caudomedian emargination; the ventral membrane spiculate. Dorsal root of basistyle long and slender, ventral root long and very slender, with pointed apex; dististyle curved, tapering distally to a bluntly pointed apex. Aedeagus with a moderately deep basal arch;

lateral arms moderately slender, directed laterally at bases; distal median process large and very broad, tapering distally to a truncate apex. Paramere with a large, laterally directed basal knob, and with a short, anteriorly directed process; stem short and stout, tapering distally to a laterally curved, pointed apex.

**Discussion.** Khamala & Kettle's (1971) *stercorarius* group appears to be loosely based on variable characters of the female. Certain similarities in wing pattern (reduced number of spots) and male genitalia do not justify this grouping. *C. pellucidus* and *parvulus*, members of the *similis* group, were placed in the *stercorarius* group in the absence of information about the structure of the male genitalia.

**Bionomics.** The immature stages of *Culicoides stercorarius* are undescribed.

In Kenya, Lubega & Khamala (1976) reared *stercorarius* from drying cow pats in open grass-

land. Khamala (1971) collected large numbers of adults by light trap in East Africa from a *Butyrospermum* savanna in Uganda and from a dry bushland and thicket zone in Kenya. Boorman & Dipeolu (1979) reported *stercorarius* was taken frequently at Vom, Nigeria.

Braverman & Hulley (1979) predicted the host preference of *stercorarius* to be larger mammals based on the low number of antennal sensilla.

**Distribution.** Kenya, Nigeria, Uganda.

**Material Examined.** UGANDA: Tororo, C. Khamala, light trap, 14-V-66, 1 ♀ paratype; Serere, C. Khamala, light trap, 18-V-66, 1 ♂ paratype.

***Culicoides walkeri* Boorman**  
(Fig. 52)

*Culicoides walkeri* Boorman 1979: 69 (female). Holotype: ♀, Kiboko, Kenya, 900 ft elev., A. R. Walker, at light, IV-72-I-73. Paratypes: 5 ♀♀, same data as holotype; 2 ♀♀, same data, III-74; 1 ♀, Makindu, A. R. Walker, XI-73 (BMNH, AVRI).

**Diagnosis.** A medium-sized, pale brown species. Female eyes almost contiguous. Female antenna with sensilla coeloconica on segments 3–14; third segment of maxillary palpus greatly expanded, with a large, deep sensory pit. Wing without pale spots. Female abdomen with 3 spermathecae, each ovoid with a long, greatly curved, sclerotized neck. Male unknown.

**Female** (described from one paratype). Wing length 0.97 mm. **Head.** Pale brown. Eyes very narrowly separated by a distance less than the diameter of ½ an ocular facet; without interfacetal setae. Antenna with flagellar lengths in proportion of 20–16–16–17–17–16–17–19–24–25–29–33–40; A.R. 1.09; sensilla coeloconica (with number per segment of paratype examined) on segments 3(4), 4(2), 5(2–3), 6(2–3), 7(2), 8(1–2), 9(2), 10(2), 11(2), 12(2), 13(2), 14(4–5). Third segment of maxillary palpus greatly expanded, with a large, rounded, deep sensory pit; P.R. 1.73. Proboscis moderately long, P/H 0.71; mandible with 14 teeth.

**Thorax.** Pale brown, without mesonotal pattern, except anterolateral margins somewhat darker, and anterior and posterior margins of scutum each with a darker mesal patch. Legs pale brown; femora weakly pale at bases; tibiae each with a weak sub-basal pale band; hindtibial comb with 4 spines, that nearest the spur longest. Halter pale.

**Wing.** Pale grayish brown; without pale spots. Macrotrichia long and moderately dense over most of wing, basal cell bare. Costal ratio 0.55.

**Abdomen.** Pale brown, last 3 segments darker. Three functional spermathecae present, subequal; each ovoid with a long, curved, sclerotized neck, about 0.053 mm long.

**Male.** Unknown.

**Discussion.** *Culicoides fulvithorax* (subgenus *Trithecodes*) is the only other species from Kenya with three functional spermathecae; *walkeri* differs

by having an unmarked wing, an antennal sensory pattern of 3–14, the third palpal segment with a single sensory pit, a brownish scutum, and ovoid spermathecae with long, curved, sclerotized necks. *Culicoides walkeri* possibly is a member of the subgenus *Pontoculicoides* Remm but should not be placed there until the male is discovered and the genitalia are studied.

**Bionomics.** The immature stages and larval habitat of *Culicoides walkeri* are undescribed. Boorman (1979) reported light trap records by Walker from Kiboko, Kenya, from April to January and March and from Makindu in November.

The adult feeding habits of *walkeri* are undescribed.

**Distribution.** Kenya.

**Material Examined.** KENYA: Makindu, A. R. Walker, at light, 29-XI-73, 1 ♀ paratype.

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## Appendix

### Systematic Arrangement of the *Culicoides* of Kenya by Subgenera and Groups

- Subgenus *Beltranmyia* Vargas  
*nivosus* De Meillon  
*pyncostictus* Ingram & Macfie
- Subgenus *Culicoides* Latreille s. str.  
*brucei* Austen  
*magnus* Colaco  
*sylvicola* Khamala & Kettle
- Subgenus *Meijerehelea* Wirth & Hubert  
*distinctipennis* Austen  
*isechnoensis* Glick, n. sp.  
*leucostictus* Kieffer
- Subgenus *Monoculicoides* Khalaf  
*cornutus* De Meillon
- Subgenus *Trithecoides* Wirth & Hubert  
*fulvithorax* (Austen)
- C. albovenosus* group  
*albovenosus* Khamala & Kettle
- C. imicola* group  
*gulbenkiani* Caeiro  
*imicola* Kieffer  
*kanagai* Khamala & Kettle  
*kibatiensis* Goetghebuer  
*pseudopallidipennis* Clastrier  
*spinifer* Khamala & Kettle  
*trifasciellus* Goetghebuer
- C. inornatipennis* group  
*nairobiensis* Glick, n. sp.
- C. milnei* group  
*giganteus* Khamala & Kettle  
*isioloensis* Cornet, Nevill & Walker  
*kerichoensis* Khamala & Kettle  
*krameri* Clastrier  
*milnei* Austen
- moreli* Clastrier  
*zuluensis* De Meillon
- C. neavei* group  
*neavei* Austen  
*ovalis* Khamala & Kettle
- C. nigripennis* group  
 sp. 7
- C. schultzei* group  
*rhizophorensis* Khamala & Kettle  
*schultzei* (Enderlein)  
 sp. 4  
 sp. 5  
 sp. 6
- C. similis* group  
*accraensis* Carter, Ingram & Macfie  
*expectator* Clastrier  
*karenensis* Glick, n. sp.  
*kobae* Cornet & Chateau  
*micheli* Cornet & Chateau  
*papillatus* Khamala & Kettle  
*parvulus* Khamala & Kettle  
*pretoriensis* Kramer & Nevill  
*radiomaculatus* Khamala & Kettle  
*ravus* De Meillon  
*similis* Carter, Ingram & Macfie  
*tropicalis* Kieffer
- Unplaced species  
*adersi* Ingram & Macfie  
*bedfordi* Ingram & Macfie  
*coarctatus* Clastrier & Wirth  
*eriodendroni* Carter, Ingram & Macfie  
*gambiae* Clastrier & Wirth  
*kaimosiensis* Khamala & Kettle  
*shimoniensis* Khamala & Kettle  
*stercorarius* Khamala & Kettle  
*walkeri* Boorman